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Ito

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(45) **Date of Patent: Dec. 3, 2013**

(54) **RADIO COMMUNICATION METHOD IN RADIO COMMUNICATION SYSTEM, TERMINAL APPARATUS, BASE STATION APPARATUS, AND RADIO COMMUNICATION SYSTEM**

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(73) Assignee: **Fujitsu Limited**, Kawasaki (JP)

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(22) Filed: **Sep. 29, 2010**

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(51) **Int. Cl.**
H04B 1/04 (2006.01)

(52) **U.S. Cl.**
USPC **455/69**; 455/102; 455/93

(58) **Field of Classification Search**
USPC 455/69, 561, 562.1, 93, 102, 103, 455/115.1; 375/295, 298
See application file for complete search history.

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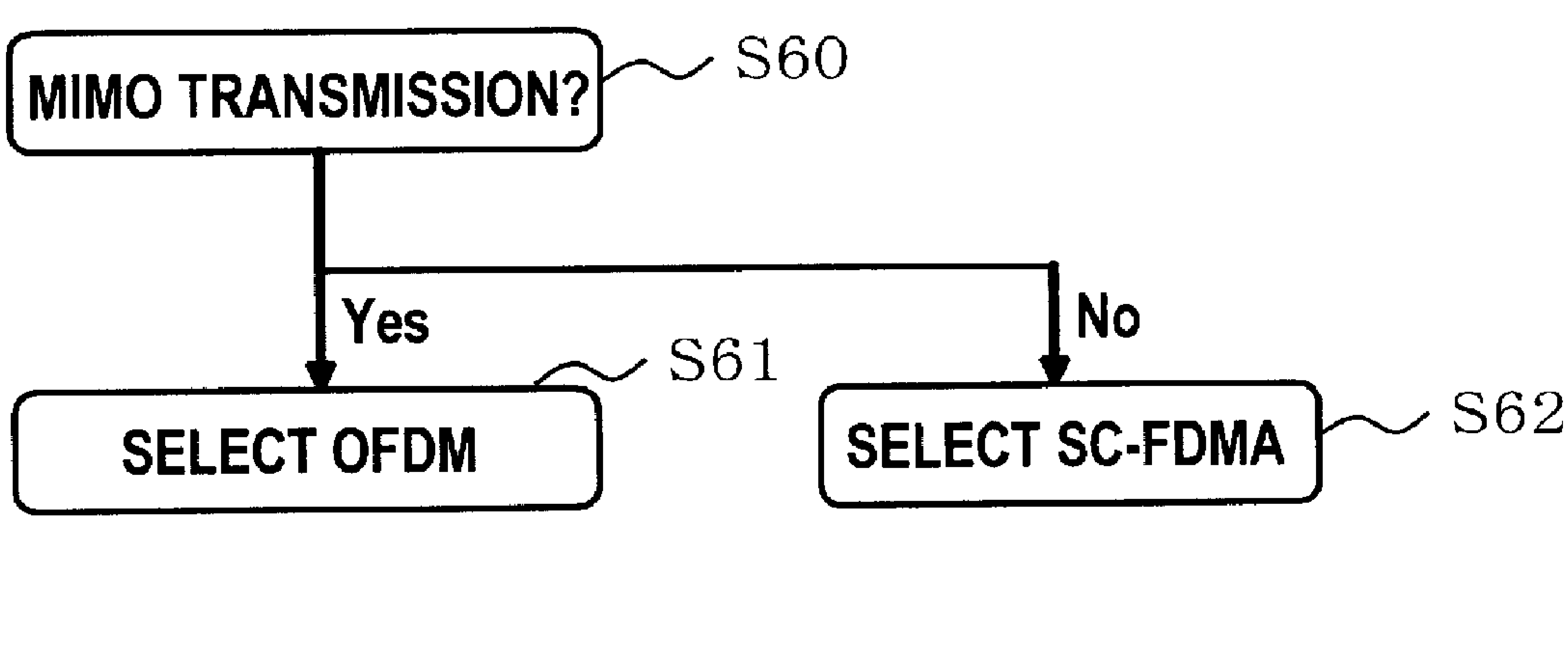
Primary Examiner — Blane J Jackson
(74) *Attorney, Agent, or Firm* — Katten Muchin Rosenman LLP

(57) **ABSTRACT**

A radio communication method in a radio communication system which performs radio communication between a terminal apparatus and a base station apparatus, the radio communication method including: selecting one of a first transmission method or a second transmission method on the basis of transmission power of transmission signal transmitted from the terminal apparatus, in the base station apparatus; and transmitting the transmission signal to the base station apparatus by the selected first or second transmission method, in the terminal apparatus.

8 Claims, 16 Drawing Sheets



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3GPP TS 36.211 V8.0.0, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (Release 8), Sep. 2007.

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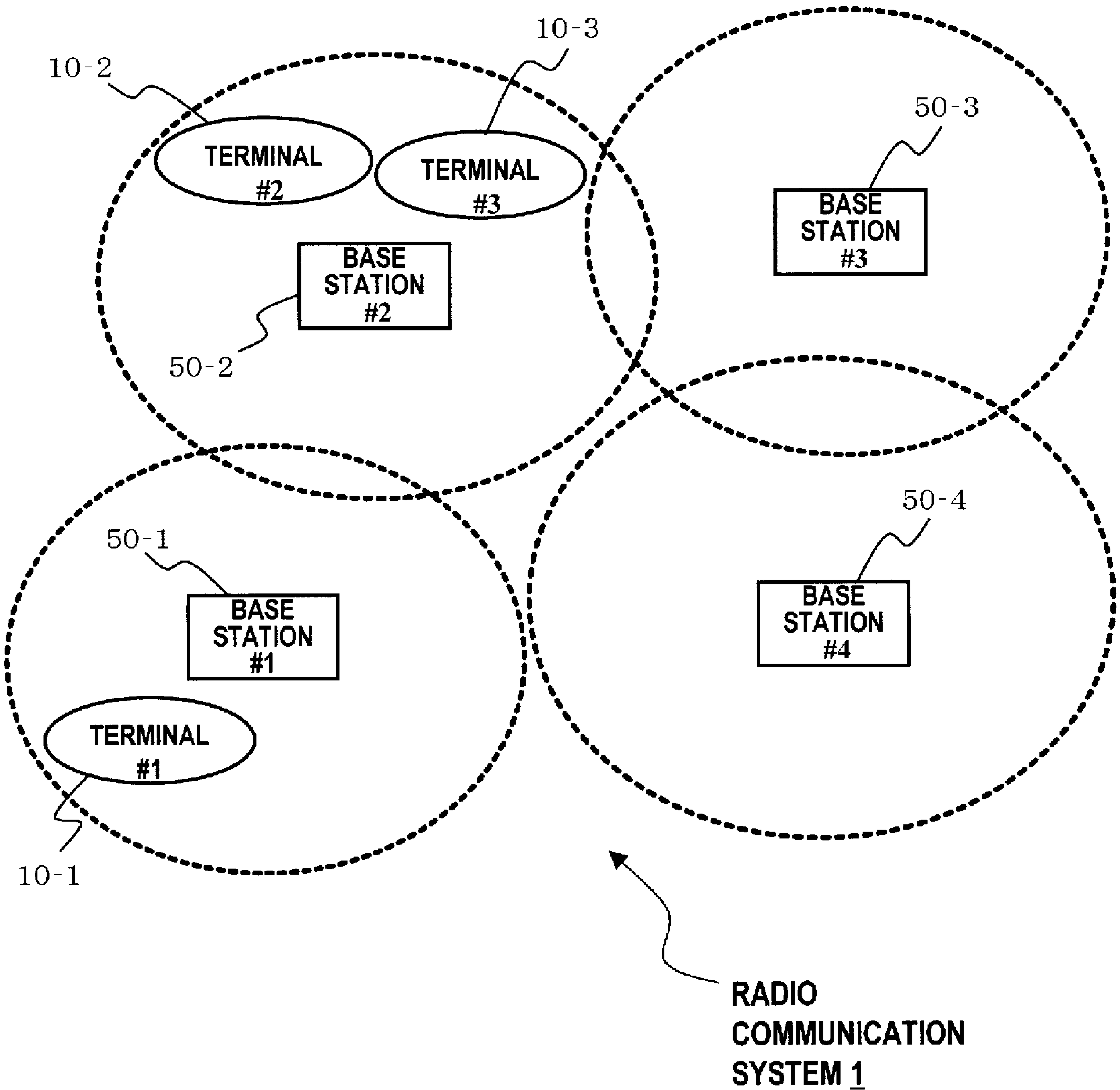
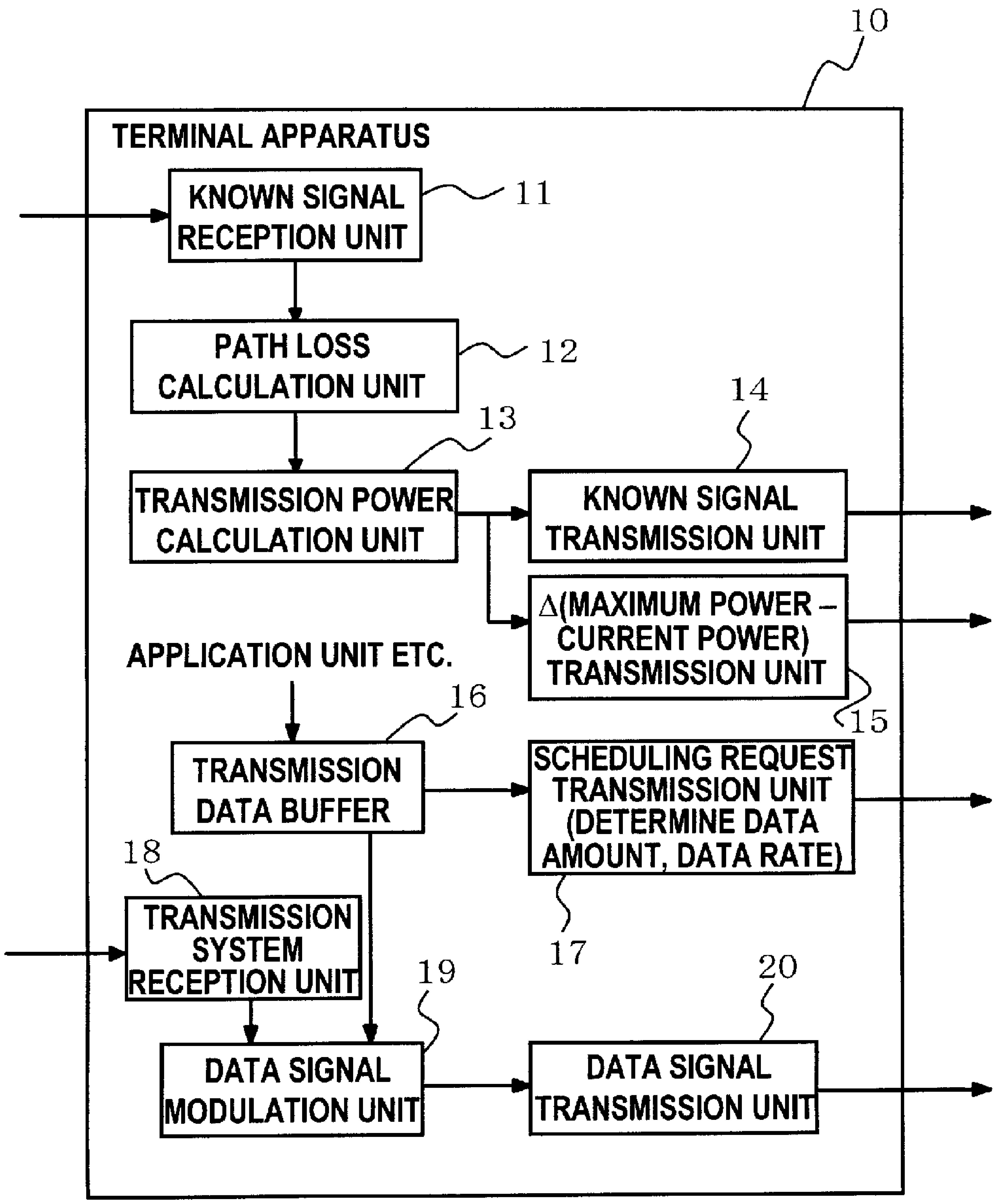
FIG. 1



10-2
10-3
TERMINAL #2
TERMINAL #3
50-3
BASE STATION #3
BASE STATION #2
50-2
50-4
50-1
BASE STATION #1
BASE STATION #4
TERMINAL #1
10-1
RADIO COMMUNICATION SYSTEM 1

FIG. 2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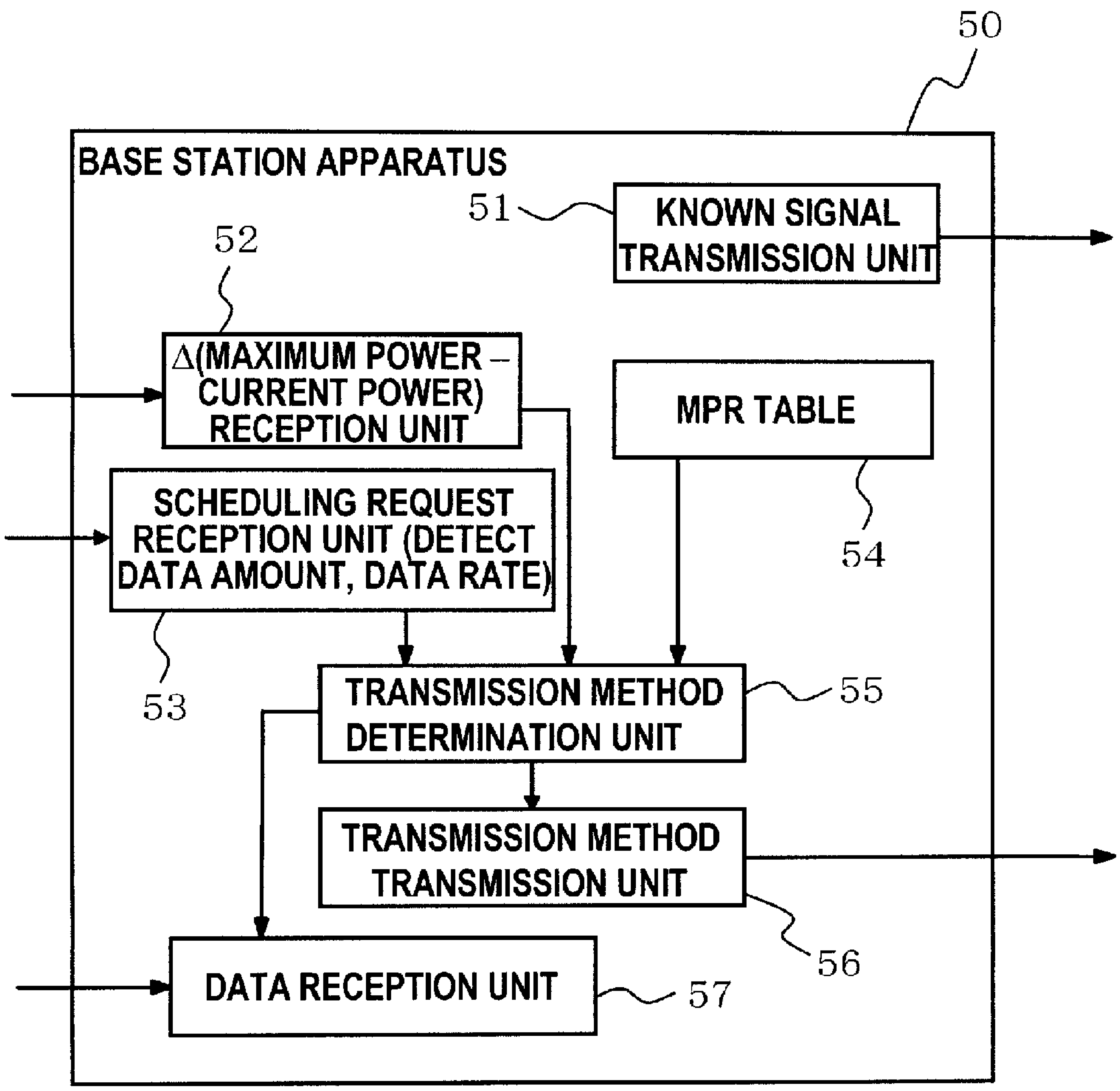
11
PATH LOSS CALCULATION UNIT
12
13
TRANSMISSION POWER CALCULATION UNIT
14
KNOWN SIGNAL TRANSMISSION UNIT
Δ(MAXIMUM POWER – CURRENT POWER) TRANSMISSION UNIT
15
APPLICATION UNIT ETC.
16
TRANSMISSION DATA BUFFER
SCHEDULING REQUEST TRANSMISSION UNIT (DETERMINE DATA AMOUNT, DATA RATE)
17
18
TRANSMISSION SYSTEM RECEPTION UNIT
19
DATA SIGNAL MODULATION UNIT
20
DATA SIGNAL TRANSMISSION UNIT

FIG. 3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BASE STATION APPARATUS
51
KNOWN SIGNAL TRANSMISSION UNIT
52
Δ(MAXIMUM POWER – CURRENT POWER) RECEPTION UNIT
MPR TABLE
54
SCHEDULING REQUEST RECEPTION UNIT (DETECT DATA AMOUNT, DATA RATE)
53
TRANSMISSION METHOD DETERMINATION UNIT
55
TRANSMISSION METHOD TRANSMISSION UNIT
56
DATA RECEPTION UNIT
57

FIG. 4

54

TRANSMISSION METHOD	MODULATION SCHEME	NUMBER OF RBs	P_r (TRANSMISSION POWER REDUCTION AMOUNT)
OFDM	QPSK	1	1dB
SC-FDMA	QPSK	1	0dB
OFDM	16QAM	1	3dB
SC-FDMA	16QAM	1	2dB
OFDM	QPSK	2	3.5dB
SC-FDMA	QPSK	2	2.5dB
OFDM	16QAM	2	4.5dB
SC-FDMA	16QAM	2	3.5dB

FIG. 5

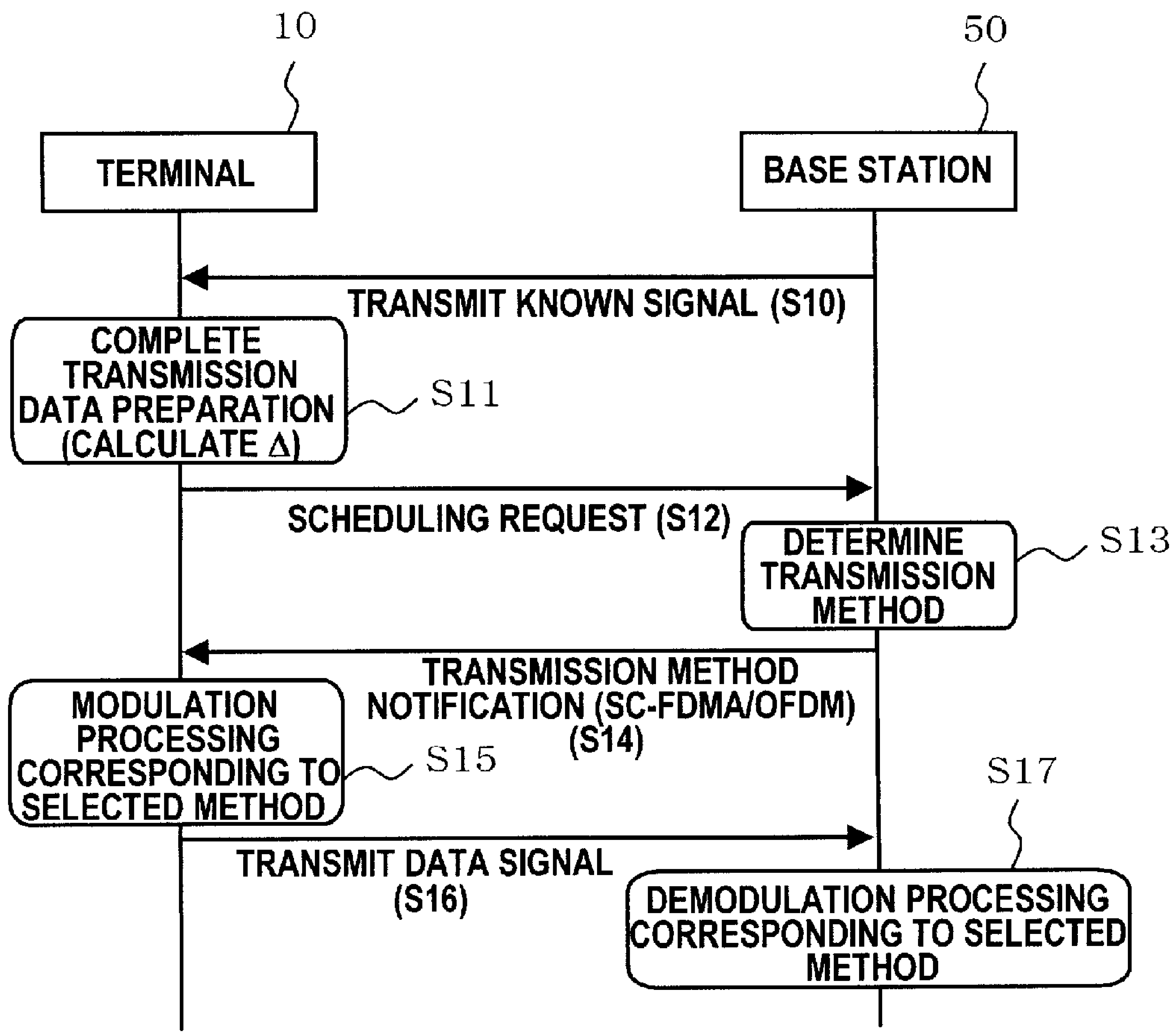

10
50
TERMINAL
BASE STATION
TRANSMIT KNOWN SIGNAL (S10)
COMPLETE TRANSMISSION DATA PREPARATION (CALCULATE Δ)
S11
SCHEDULING REQUEST (S12)
DETERMINE TRANSMISSION METHOD
S13
TRANSMISSION METHOD NOTIFICATION (SC-FDMA/OFDM) (S14)
MODULATION PROCESSING CORRESPONDING TO SELECTED METHOD
S15
S17
TRANSMIT DATA SIGNAL (S16)
DEMODULATION PROCESSING CORRESPONDING TO SELECTED METHOD

FIG. 6

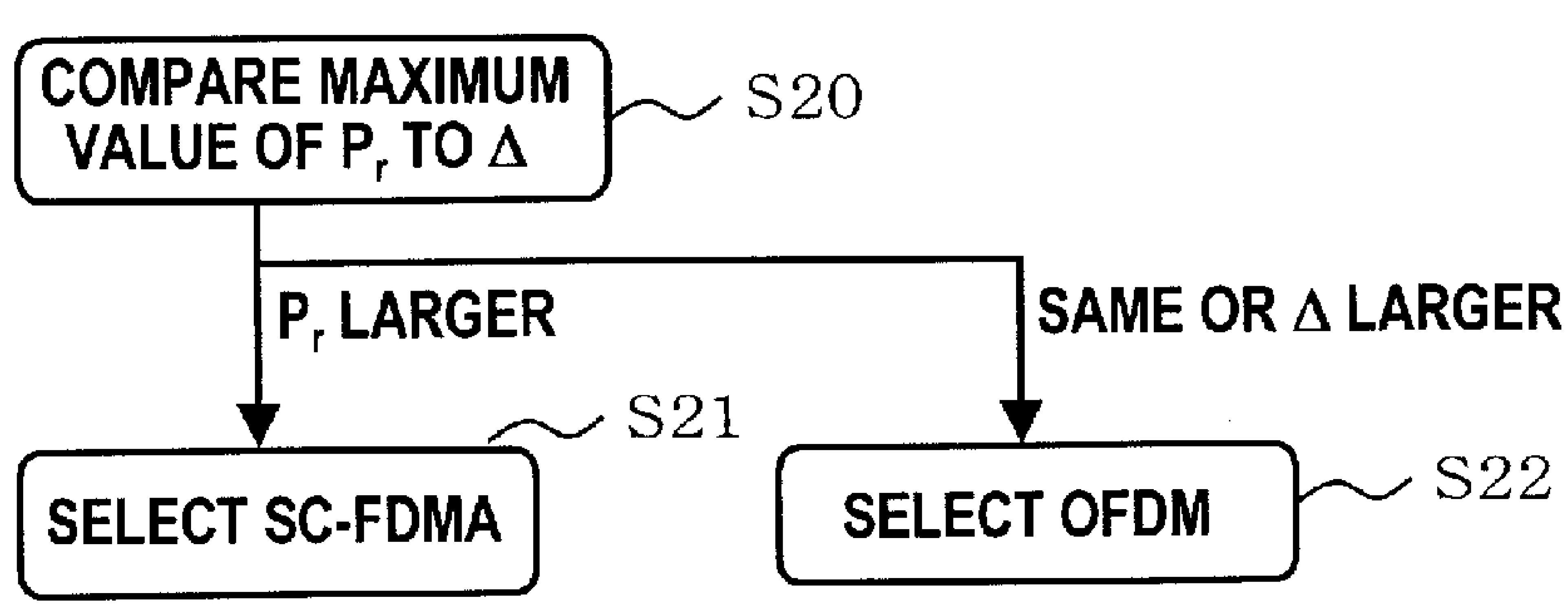

COMPARE MAXIMUM VALUE OF P$_r$ TO Δ
S20
P$_r$ LARGER
SAME OR Δ LARGER
S21
SELECT SC-FDMA
SELECT OFDM
S22

FIG. 7A

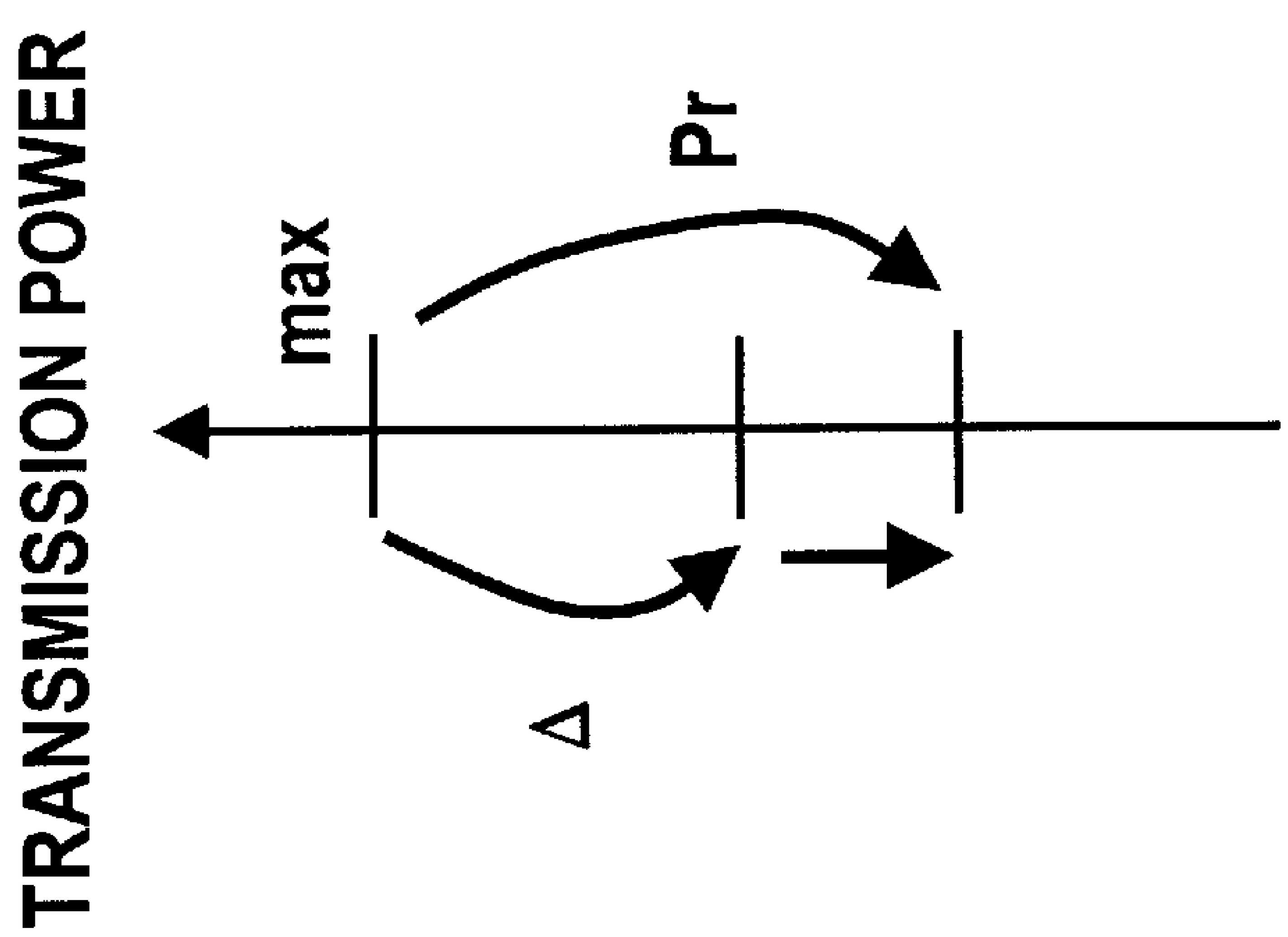


FIG. 7B

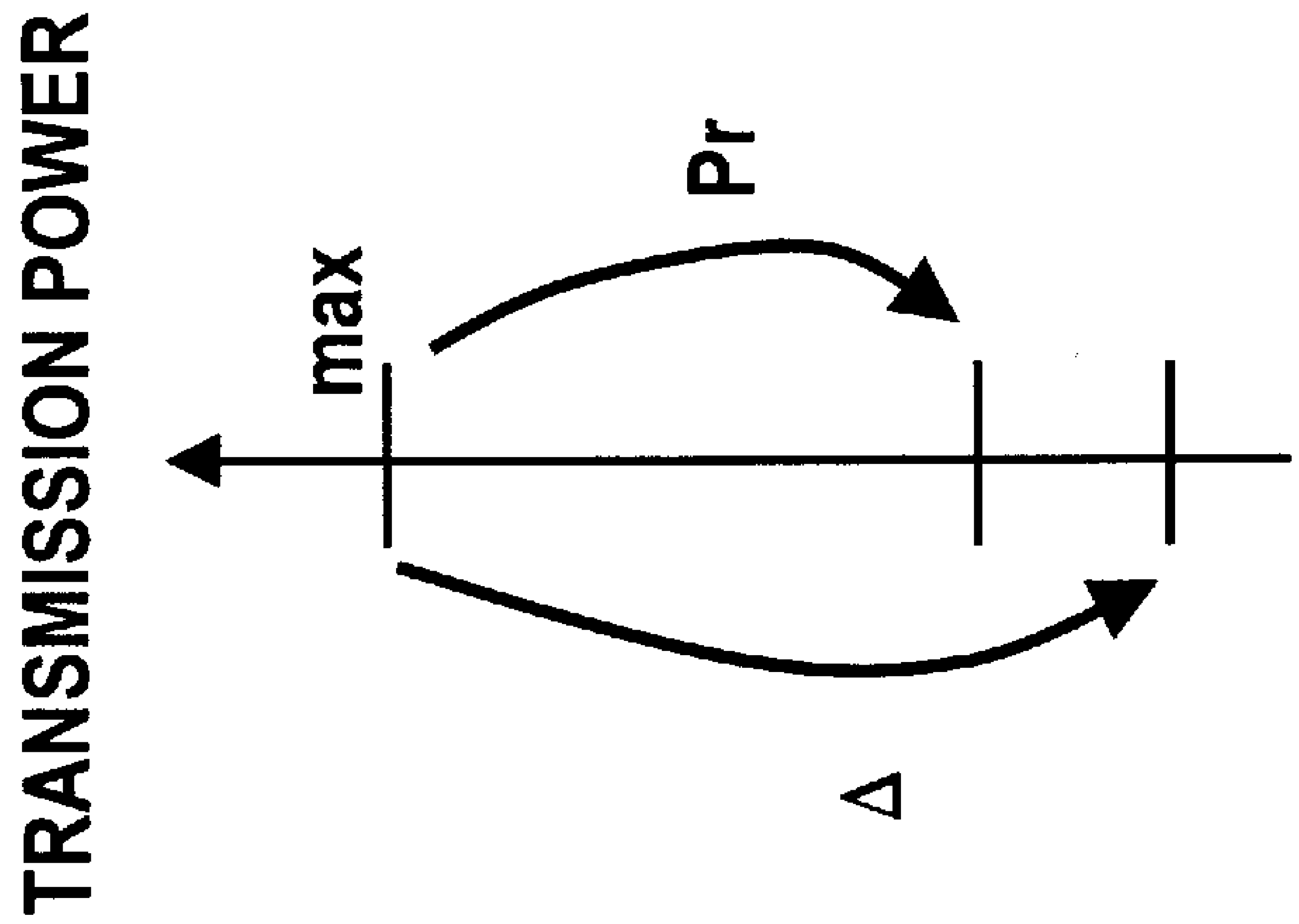


FIG. 8

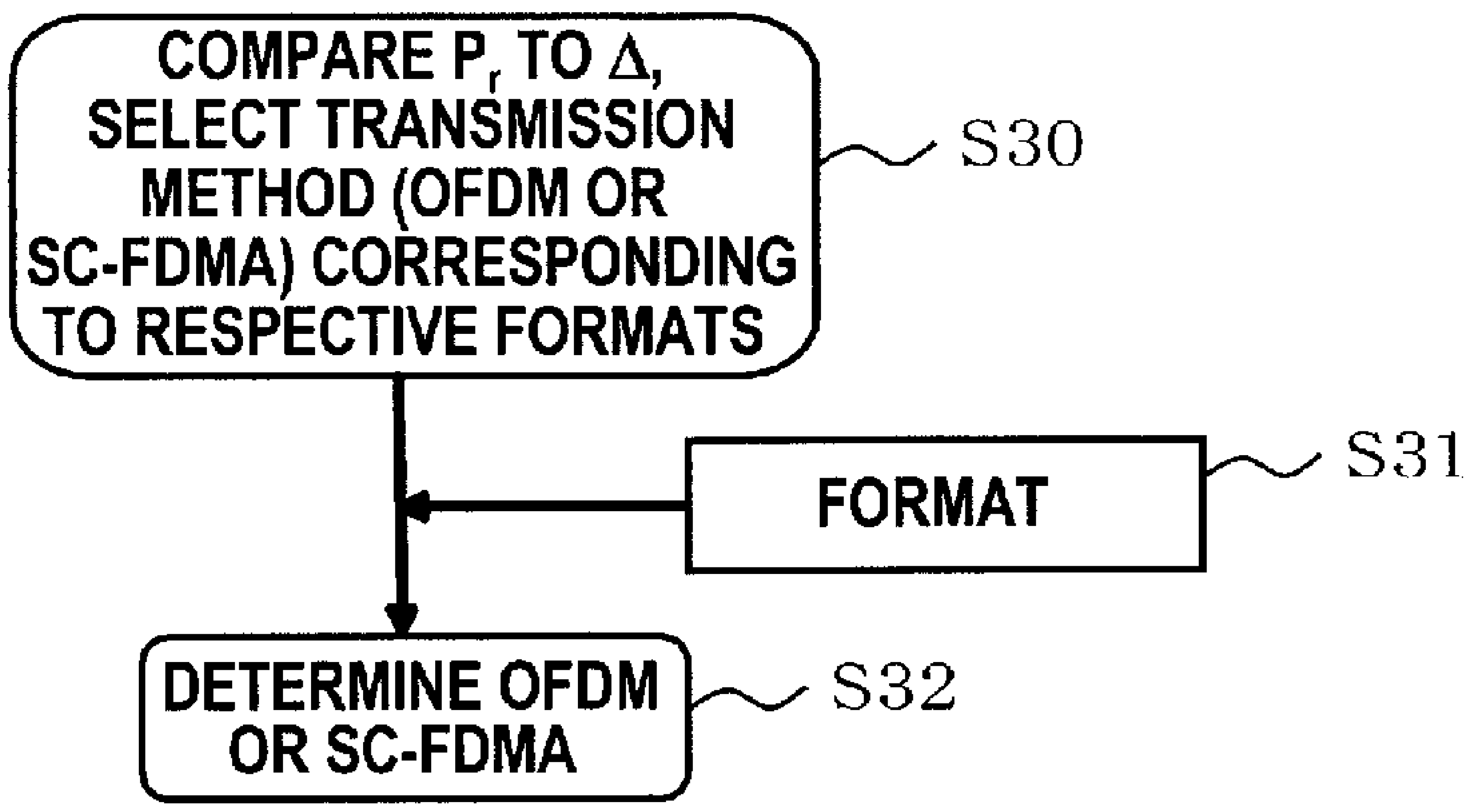


FIG. 9

54

MODULATION SCHEME	NUMBER OF RBs	TRANSMISSION METHOD	P_r (TRANSMISSION POWER REDUCTION AMOUNT)
16QAM	1	OFDM	3dB
16QAM	1	SC-FDMA	2dB

FIG. 10

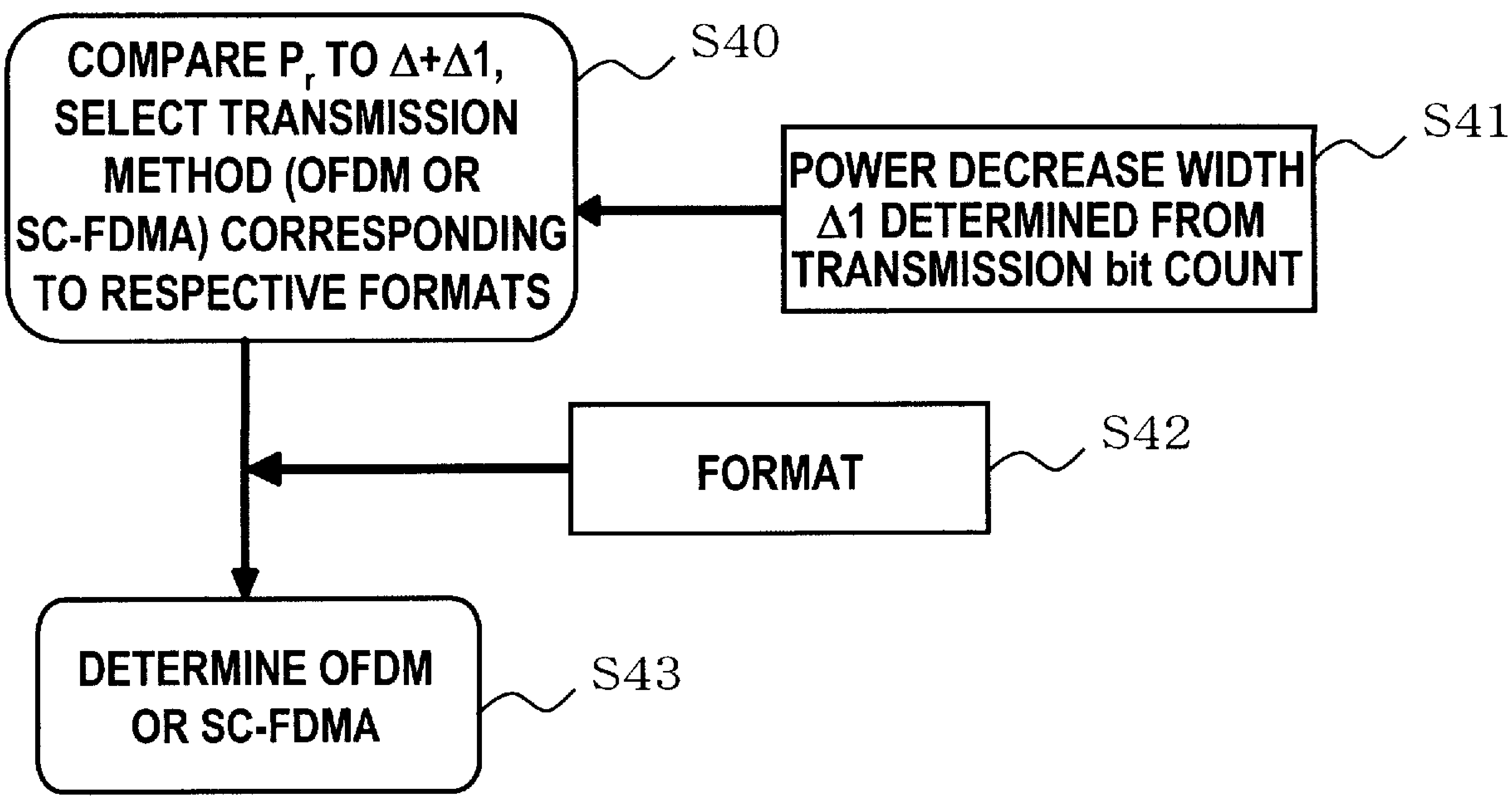

COMPARE P_r TO Δ+Δ1, SELECT TRANSMISSION METHOD (OFDM OR SC-FDMA) CORRESPONDING TO RESPECTIVE FORMATS
S40
POWER DECREASE WIDTH Δ1 DETERMINED FROM TRANSMISSION bit COUNT
S41
FORMAT
S42
DETERMINE OFDM OR SC-FDMA
S43

FIG. 11

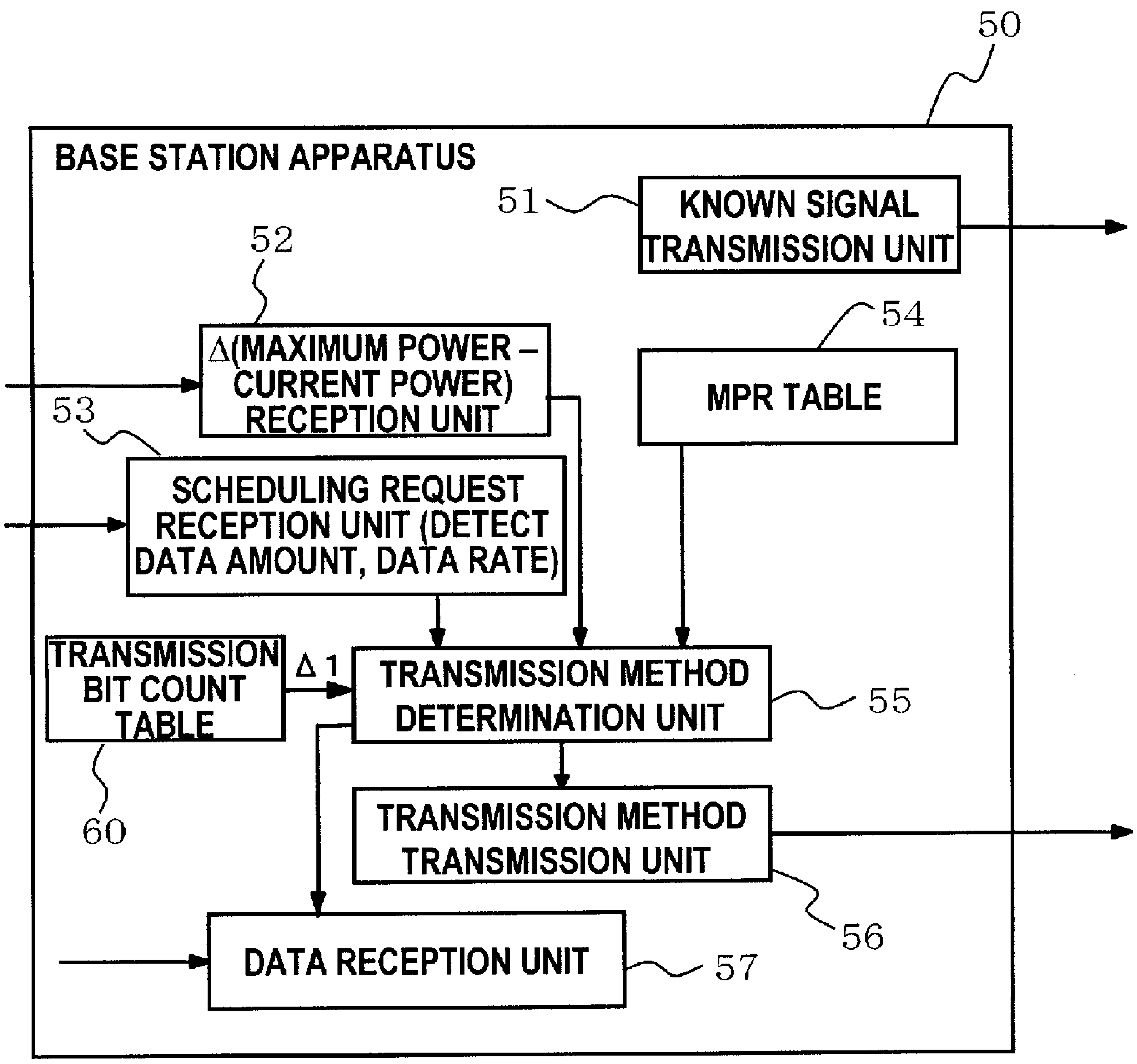
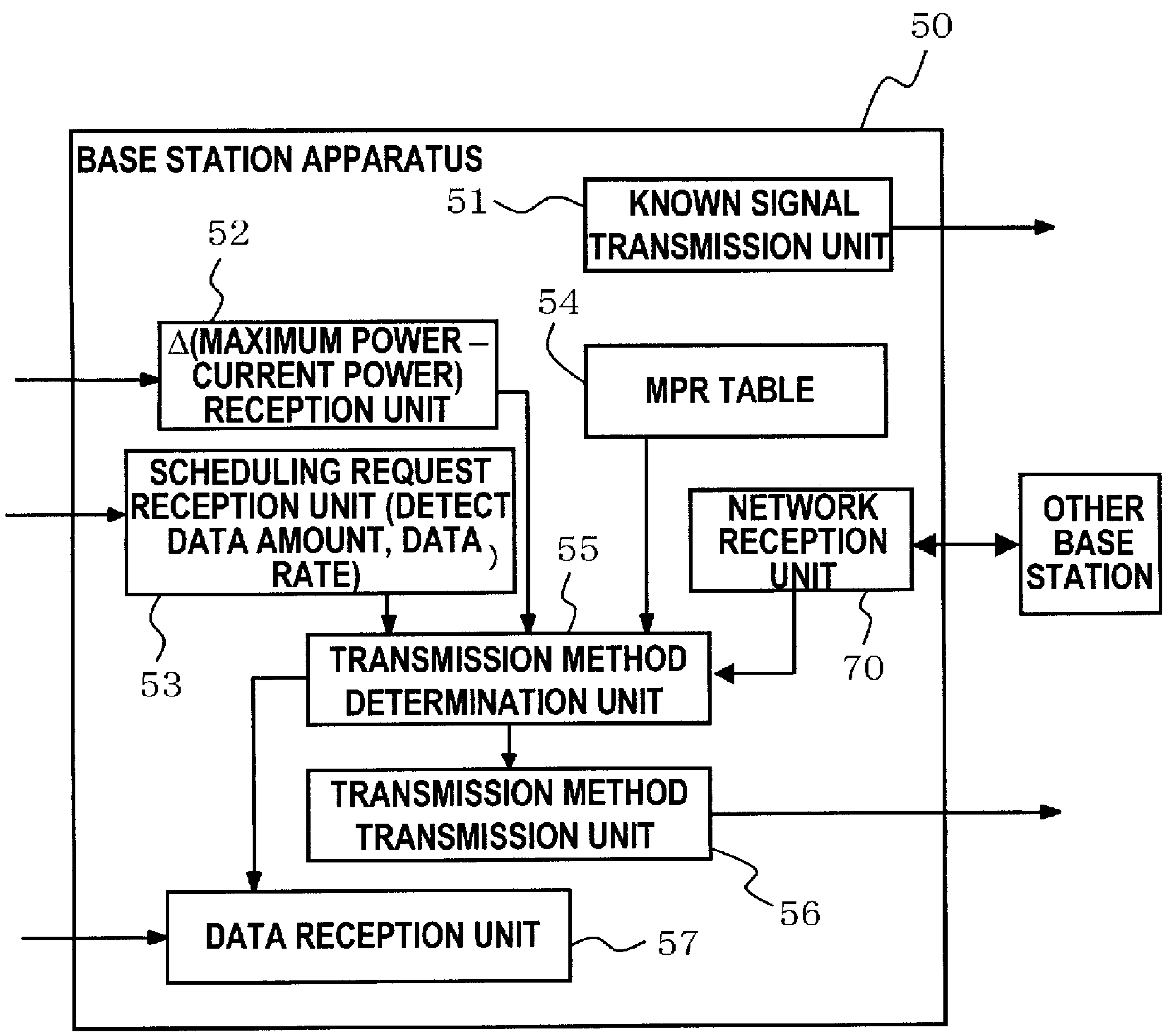

50
BASE STATION APPARATUS
51
KNOWN SIGNAL TRANSMISSION UNIT
52
Δ(MAXIMUM POWER – CURRENT POWER) RECEPTION UNIT
54
MPR TABLE
53
SCHEDULING REQUEST RECEPTION UNIT (DETECT DATA AMOUNT, DATA RATE)
TRANSMISSION BIT COUNT TABLE
Δ 1
TRANSMISSION METHOD DETERMINATION UNIT
55
60
TRANSMISSION METHOD TRANSMISSION UNIT
56
DATA RECEPTION UNIT
57

FIG. 12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BASE STATION APPARATUS
51
KNOWN SIGNAL TRANSMISSION UNIT
52
Δ(MAXIMUM POWER – CURRENT POWER) RECEPTION UNIT
54
MPR TABLE
SCHEDULING REQUEST RECEPTION UNIT (DETECT DATA AMOUNT, DATA RATE)
NETWORK RECEPTION UNIT
OTHER BASE STATION
55
53
TRANSMISSION METHOD DETERMINATION UNIT
70
TRANSMISSION METHOD TRANSMISSION UNIT
56
DATA RECEPTION UNIT
57

FIG. 13

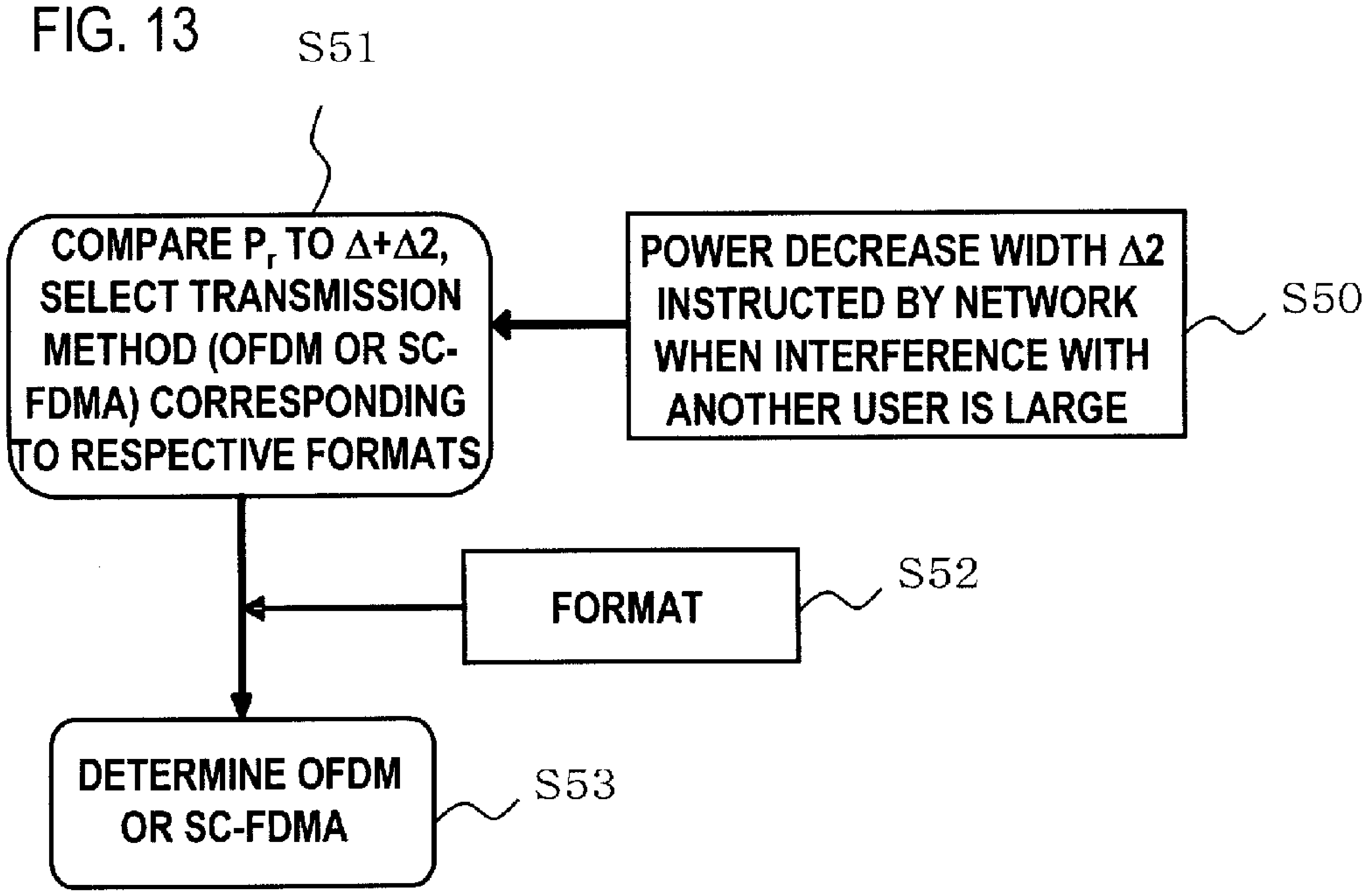

S51
COMPARE P_r TO $\Delta+\Delta 2$, SELECT TRANSMISSION METHOD (OFDM OR SC-FDMA) CORRESPONDING TO RESPECTIVE FORMATS
POWER DECREASE WIDTH $\Delta 2$ INSTRUCTED BY NETWORK WHEN INTERFERENCE WITH ANOTHER USER IS LARGE
S50
FORMAT
S52
DETERMINE OFDM OR SC-FDMA
S53

FIG. 14

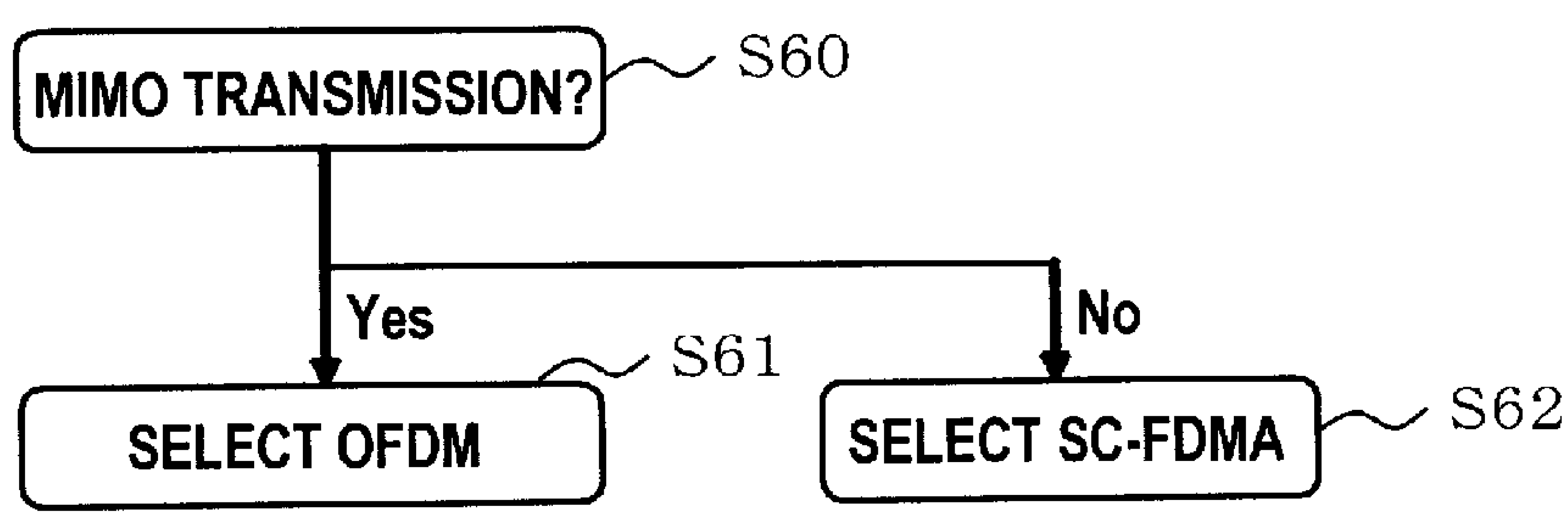
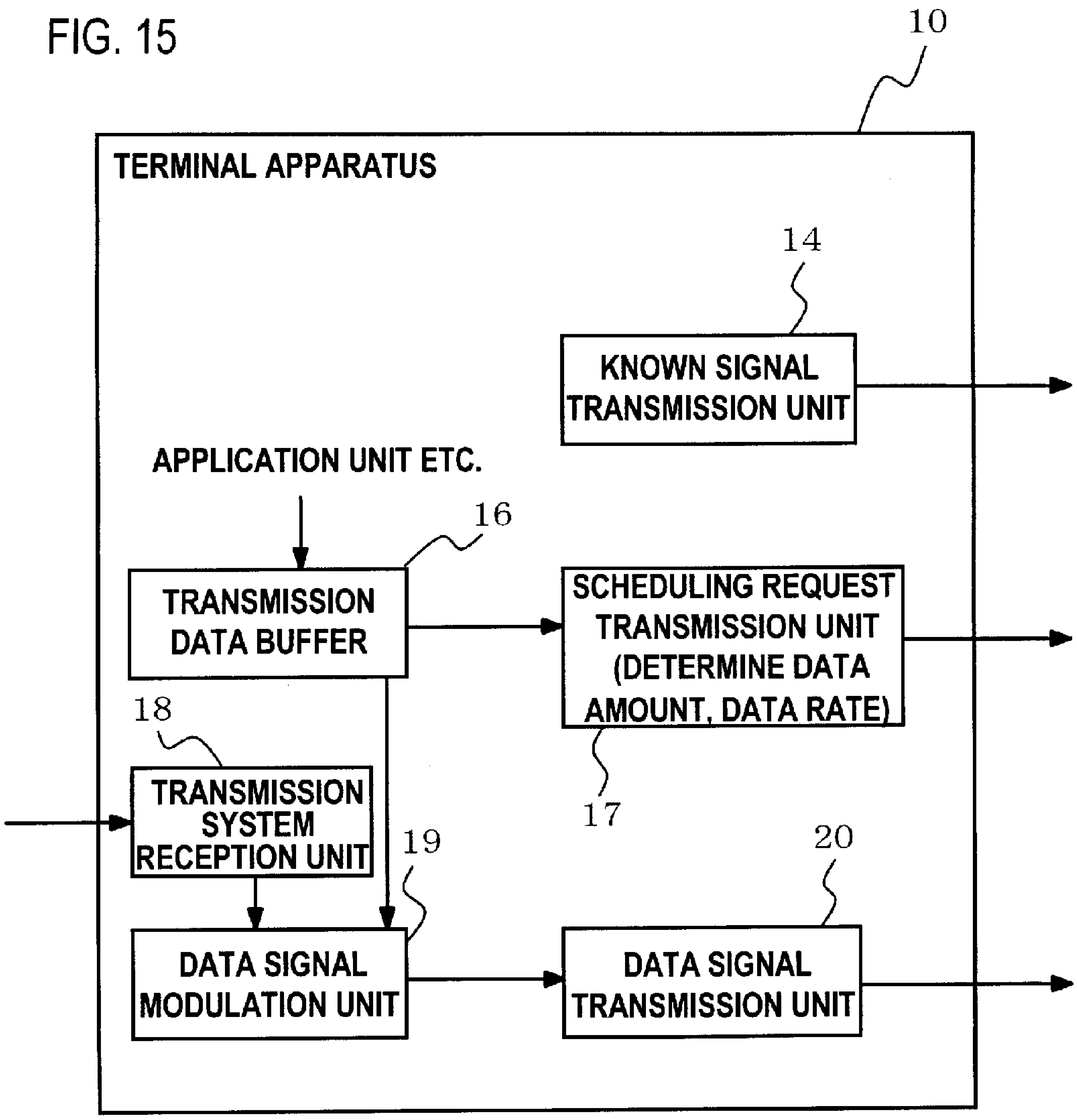

MIMO TRANSMISSION?
S60
Yes
No
SELECT OFDM
S61
SELECT SC-FDMA
S62

FIG. 15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TERMINAL APPARATUS
14
KNOWN SIGNAL TRANSMISSION UNIT
APPLICATION UNIT ETC.
16
TRANSMISSION DATA BUFFER
SCHEDULING REQUEST TRANSMISSION UNIT (DETERMINE DATA AMOUNT, DATA RATE)
17
18
TRANSMISSION SYSTEM RECEPTION UNIT
19
20
DATA SIGNAL MODULATION UNIT
DATA SIGNAL TRANSMISSION UNIT

FIG. 16

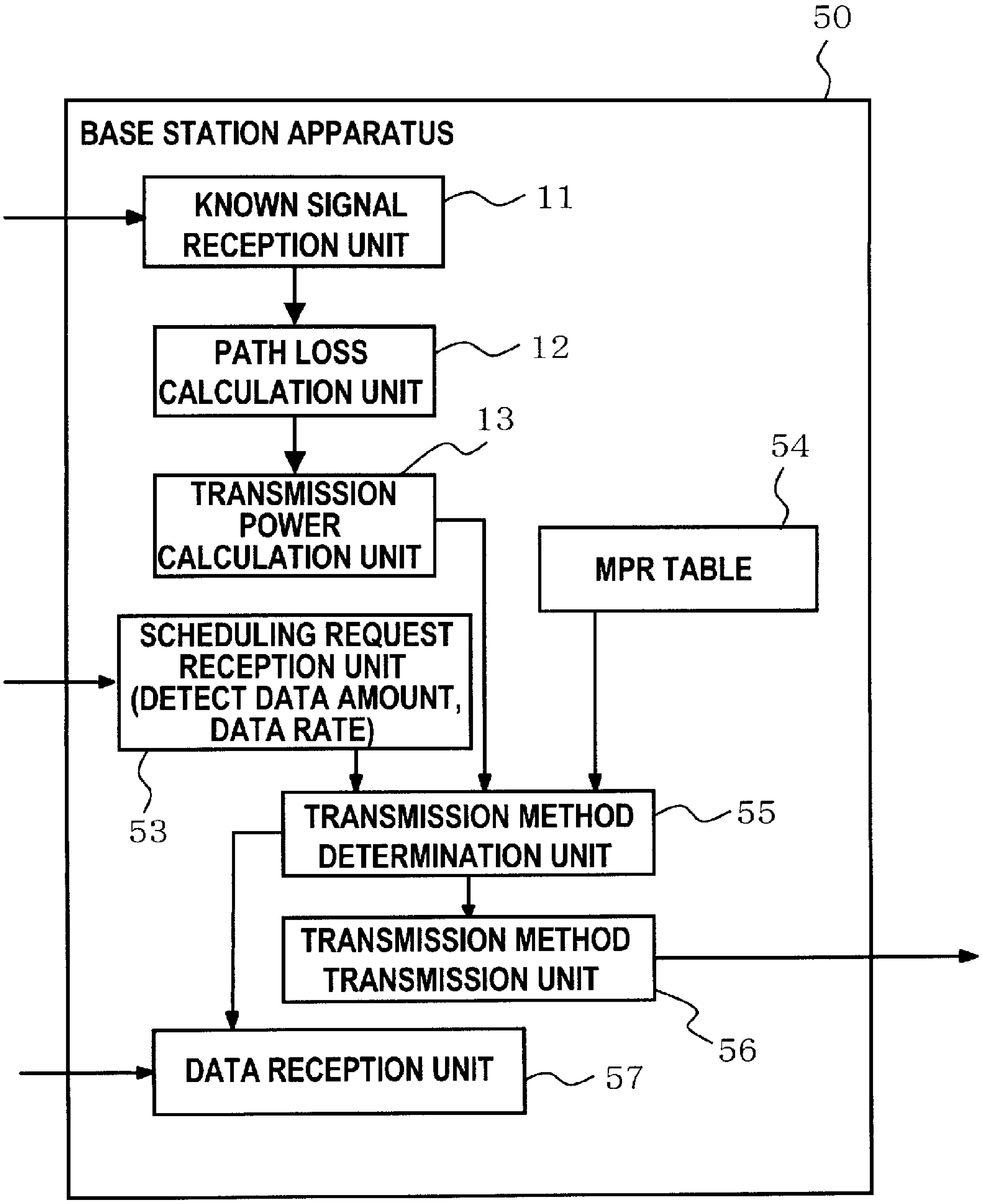

50
BASE STATION APPARATUS
KNOWN SIGNAL RECEPTION UNIT
11
PATH LOSS CALCULATION UNIT
12
13
TRANSMISSION POWER CALCULATION UNIT
54
MPR TABLE
SCHEDULING REQUEST RECEPTION UNIT (DETECT DATA AMOUNT, DATA RATE)
53
TRANSMISSION METHOD DETERMINATION UNIT
55
TRANSMISSION METHOD TRANSMISSION UNIT
56
DATA RECEPTION UNIT
57

FIG. 17

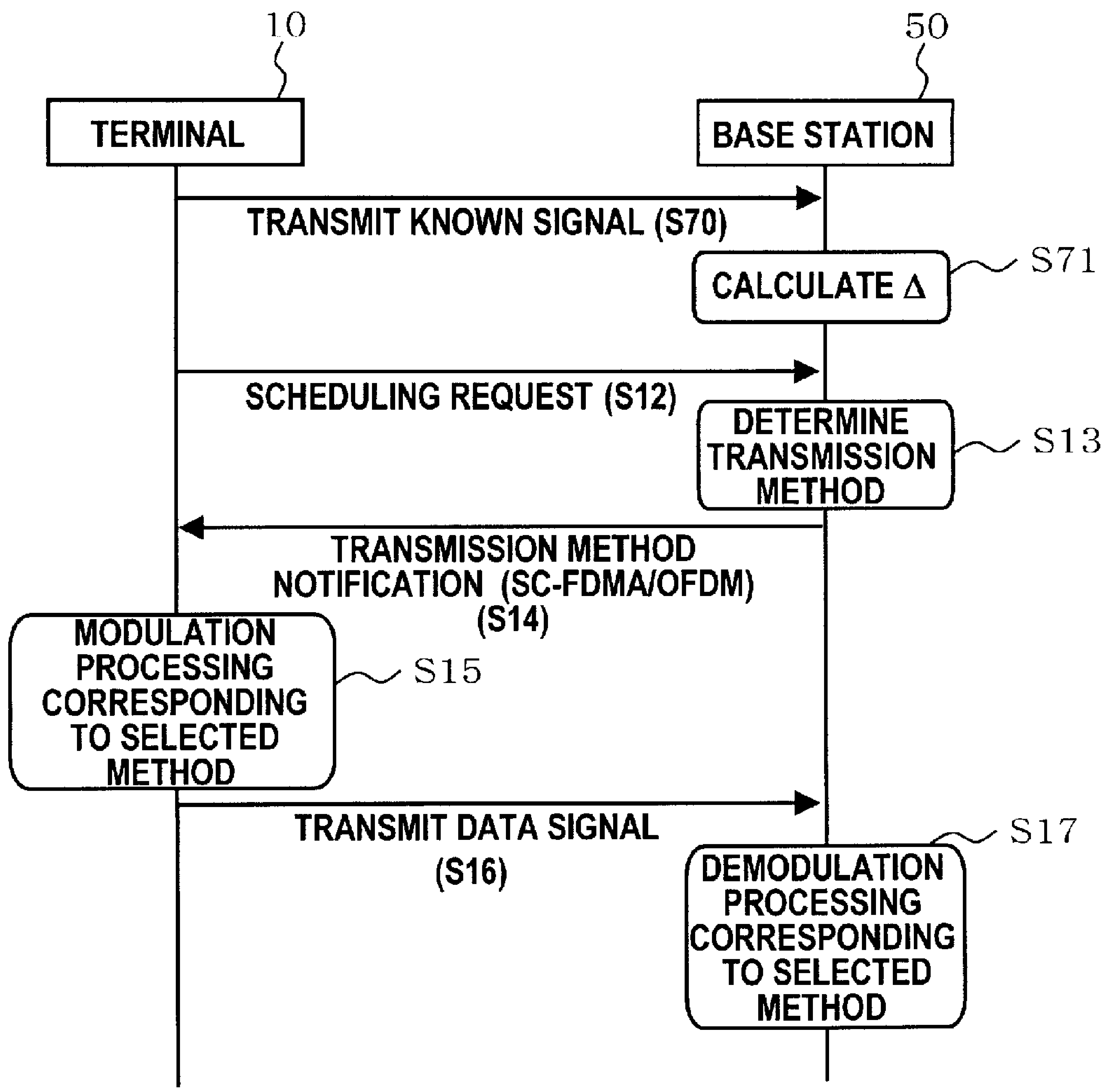

10
50
TERMINAL
BASE STATION
TRANSMIT KNOWN SIGNAL (S70)
CALCULATE Δ
S71
SCHEDULING REQUEST (S12)
DETERMINE TRANSMISSION METHOD
S13
TRANSMISSION METHOD NOTIFICATION (SC-FDMA/OFDM) (S14)
MODULATION PROCESSING CORRESPONDING TO SELECTED METHOD
S15
TRANSMIT DATA SIGNAL (S16)
S17
DEMODULATION PROCESSING CORRESPONDING TO SELECTED METHOD

FIG. 18

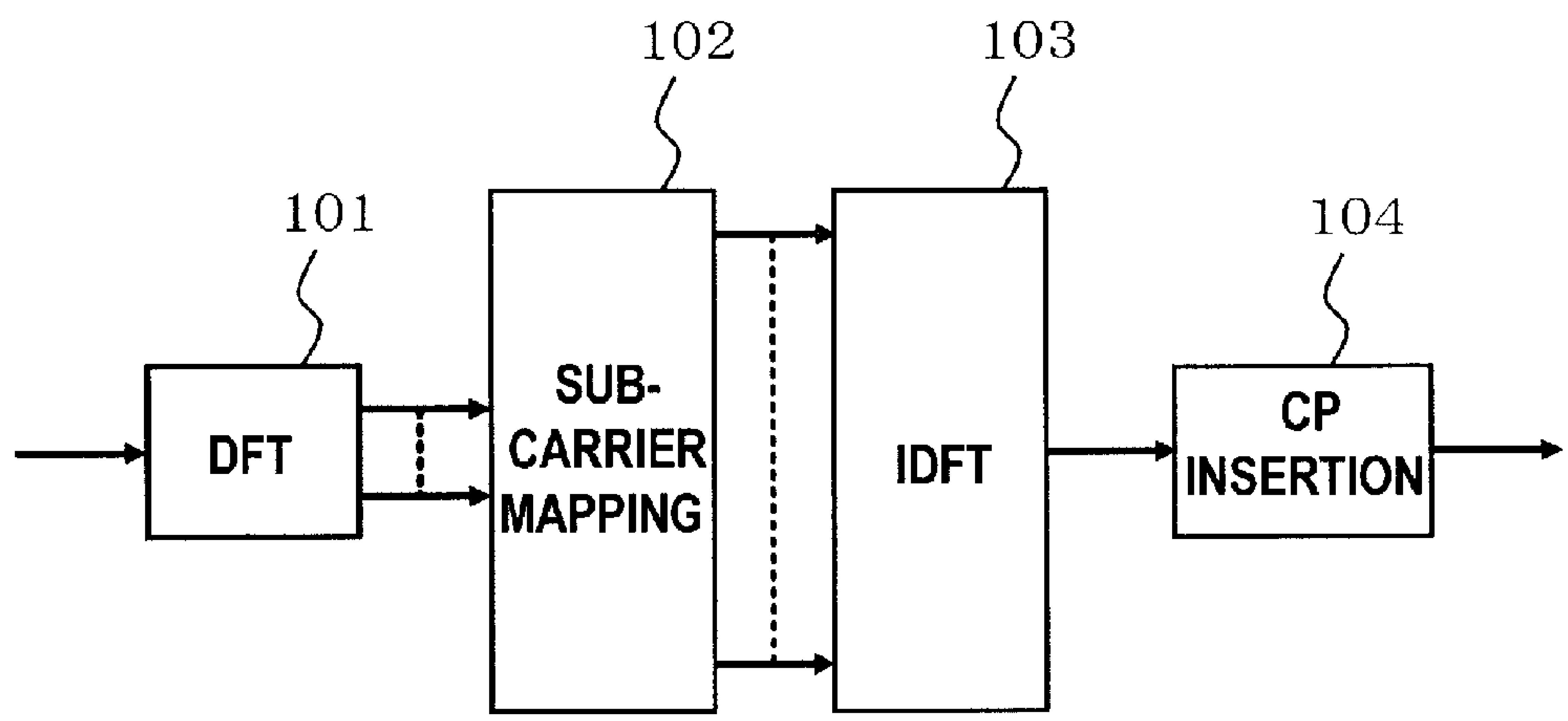

102
103
101
104
DFT
SUB-
CARRIER
MAPPING
IDFT
CP
INSERTION

FIG. 19

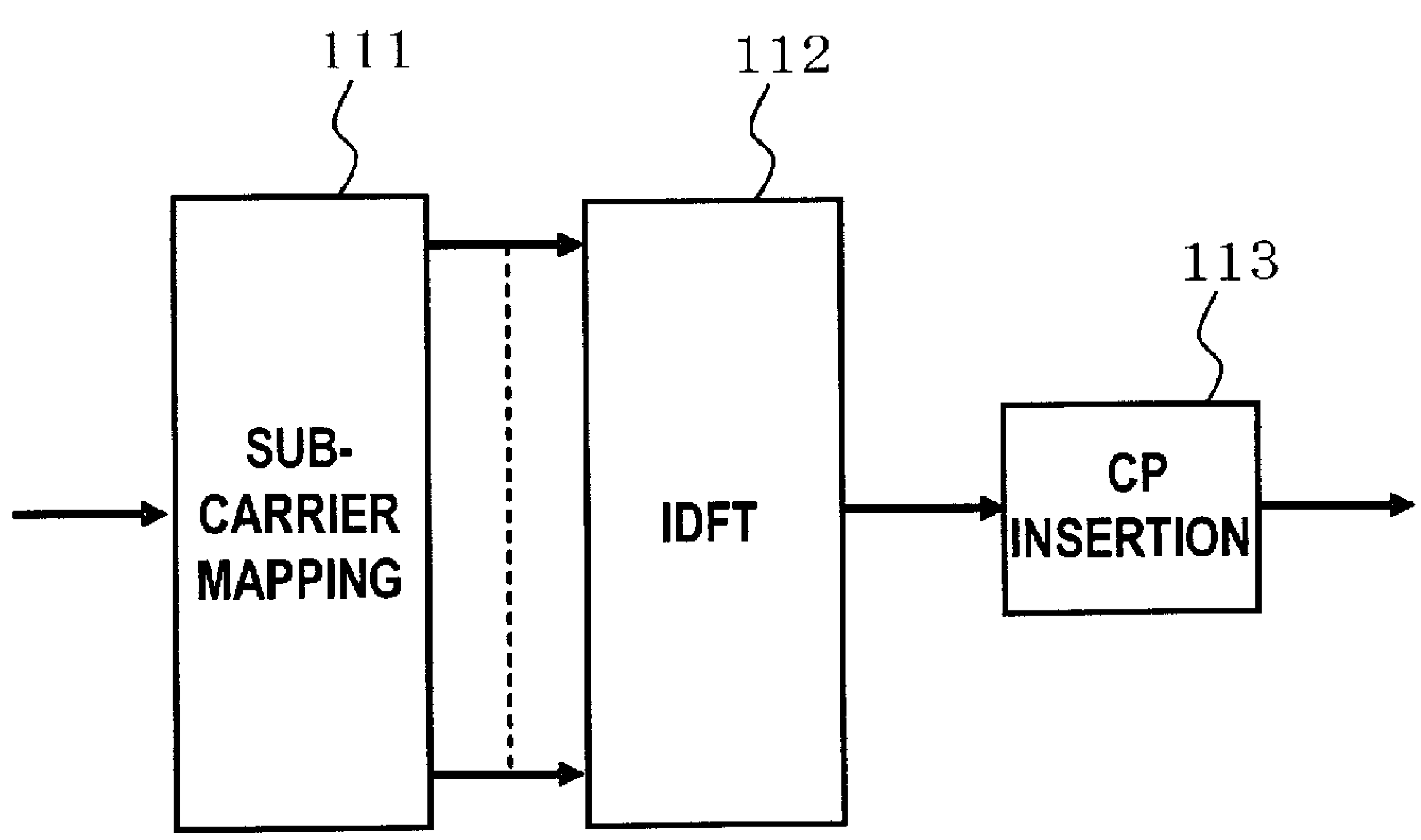
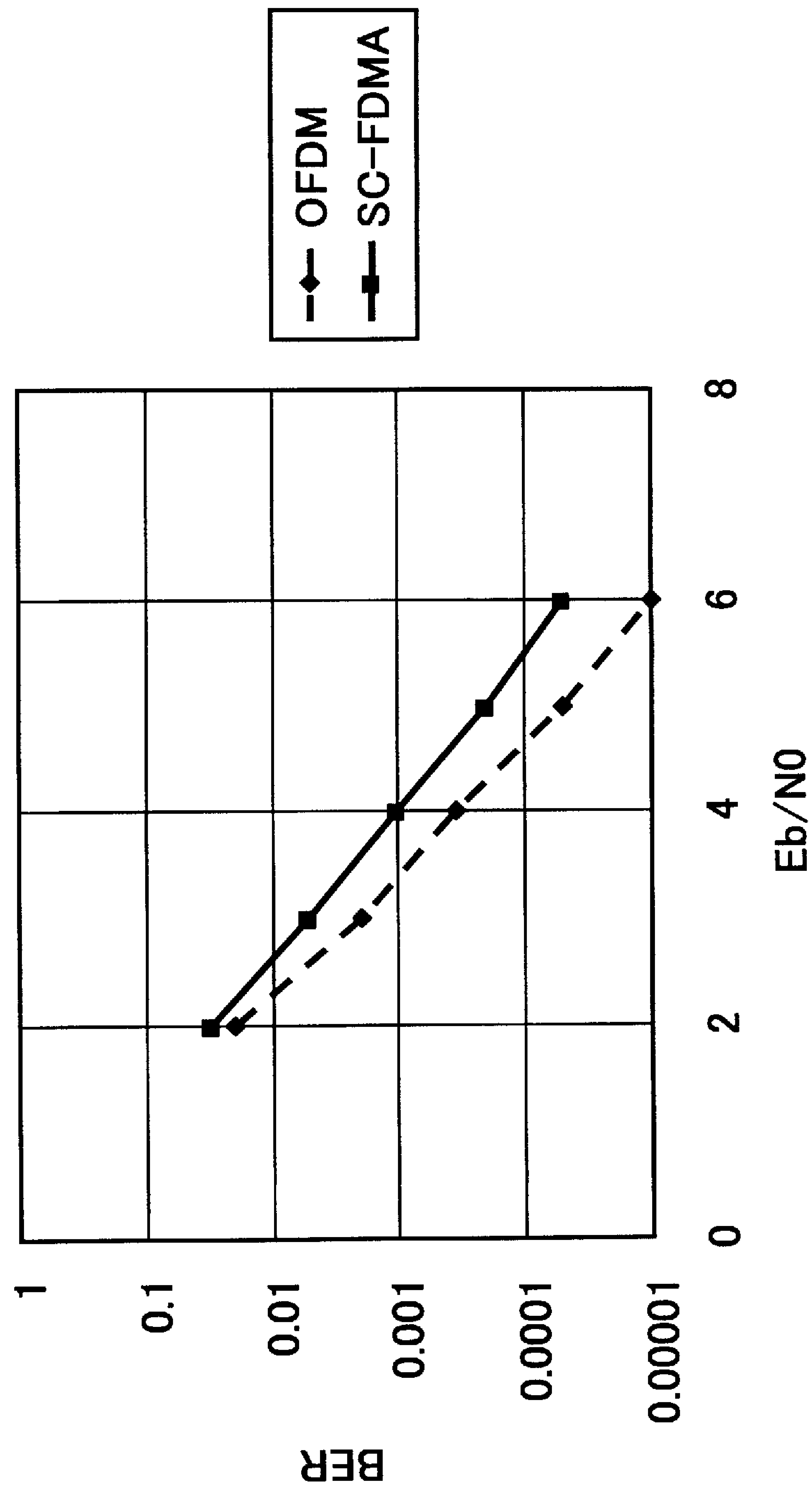

111
112
113
SUB-
CARRIER
MAPPING
IDFT
CP
INSERTION

FIG. 20



RADIO COMMUNICATION METHOD IN RADIO COMMUNICATION SYSTEM, TERMINAL APPARATUS, BASE STATION APPARATUS, AND RADIO COMMUNICATION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of International Application No. PCT/JP2008/000717, filed on Mar. 25, 2008, now pending, herein incorporated by reference.

TECHNICAL FIELD

The present invention relates to a radio communication method, a terminal apparatus, a base station apparatus, and a radio communication system.

BACKGROUND ART

In 3GPP (3rd Generation Partnership Project), LTE (Long Term Evolution, or Evaluated UTRA and UTRAN) is under investigation as a next-generation radio communication standard (Non-Patent Document 1 illustrated below, for example).

In LTE, OFDM (Orthogonal Frequency Division Multiplexing) is utilized for a downlink from a base station to a terminal, and SC-FDMA (Single-Carrier Frequency Division Multiple Access) is utilized for an uplink from the terminal to the base station.

The OFDM is a transmission method in which a frequency band is divided into a plurality of sub-carriers and data are transmitted while carried directly on each sub-carrier. On the other hand, the SC-FDMA is a transmission method in which data transformed by DFT (Discrete Fourier Transform) is carried on the sub-carrier and is transmitted. FIG. **18** and FIG. **19** illustrate configuration examples of signal processing circuits employed in SC-FDMA and OFDM, respectively. Referring to FIG. **18**, a DFT (Discrete Fourier Transform) unit **101** is included in front of a sub-carrier mapping unit, and DFT-processed signal is input successively into the sub-carrier mapping unit **102**, an IDFT (Inverse Discrete Fourier Transform) unit **103**, and a CP (Cyclic Prefix) insertion unit **104**. Referring to FIG. **19**, transmission data is input into a sub-carrier mapping unit **111** and then input successively into an IDFT unit **112** and a CP insertion unit **113**.

On the other hand, the base station or the terminal uses an amplifier to transmit data. The amplifier has a problem that linearity cannot be maintained and the data are distorted, when an input power is large. When the data are distorted, out-of-band emission power increases. An upper limit value of the out-of-band emission power (hereinafter, "ACLR") is determined by an ACLR (Adjacent Carrier Leakage Ratio) standard, and when the data distortion is large, the ACLR can no longer be satisfied.

In consideration of the ACLR, the SC-FDMA is a favorable method due to its low PAPR (Peak to Average Power Ratio), and therefore SC-FDMA is applied to the uplink from the terminal in LTE.

Non-Patent Document 1: 3GPP TS 36. 211V8. 0. 0 (2007-09)

Non-Patent Document 2: Hikmet Sari, Geroges Karam and Isabell Jeanclaude, "Transmission Techniques for Digital Terrestrial TV Broadcasting", IEEE Communication Magazine, pp. 100-109, February 1995

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

Although the SC-FDMA is advantageous in terms of the PAPR, because the sub-carrier which is continuous on a frequency axis is used, the sub-carrier cannot be selected non-continuously on the frequency axis, and the SC-FDMA has a constraint in terms of scheduling during resource allocation and the like. Also, as illustrated in FIG. **20** (Non-Patent Document 2, for example), errors are likely to occur in relation to another method even under an identical reception E/N condition.

Accordingly, it is an object of the present invention to improve inconvenient which occurs when the SC-FDMA is applied.

More preferably, it is an object to improve in consideration of scheduling flexibility or quality when the SC-FDMA is applied.

Means for Solving the Problem

According to an aspect of the present invention, a radio communication method in a radio communication system which performs radio communication between a terminal apparatus and a base station apparatus, the radio communication method including: selecting one of a first transmission method or a second transmission method on the basis of transmission power of transmission signal transmitted from the terminal apparatus, in the base station apparatus; and transmitting the transmission signal to the base station apparatus by the selected first or second transmission method, in the terminal apparatus.

Also, according to an another aspect of the present invention, a radio communication method in a radio communication system which performs radio communication between a terminal apparatus and a base station apparatus, the radio communication method including: selecting a first transmission method if the terminal apparatus transmits transmission signal by MIMO or selecting a second transmission method if not, in the base station apparatus; and transmitting the transmission signal to the base station apparatus by the selected first or second transmission method, in the terminal apparatus.

Furthermore, according to an another aspect of the present invention, a terminal apparatus for performing radio communication with a base station apparatus, the terminal apparatus including: a reception unit which receives from the base station apparatus transmission method selection information indicating selected transmission method, which is selected one of a first transmission method or a second transmission method on the basis of transmission power of transmission signal transmitted from the terminal apparatus; and a transmission unit which transmits the transmission signal to the base station apparatus by the first or second transmission method on the basis of the transmission method selection information.

Furthermore, according to an another aspect of the present invention, a terminal apparatus for performing radio communication with a base station apparatus, the terminal apparatus including: a reception unit which receives from the base station apparatus transmission method selection information indicating that a first transmission method is selected if the terminal apparatus transmits by MIMO or a second transmission method is selected if not; and a transmission unit which transmits the transmission signal to the base station apparatus by the first or second transmission method on the basis of the transmission method selection information.

Furthermore, according to an another aspect of the present invention, a base station apparatus for performing radio communication with a terminal apparatus, the base station apparatus including: a selection unit which selects one of a first transmission method or a second transmission method on the basis of transmission power of transmission signal transmitted from the terminal apparatus; and a transmission unit which transmits transmission method selection information indicating the selected first or second transmission method to the terminal apparatus, wherein the terminal apparatus transmits the transmission signal by the selected first or second transmission method.

Furthermore, according to an another aspect of the present invention, a base station apparatus for performing radio communication with a terminal apparatus, the base station apparatus including: a selection unit which selects a first transmission method if the terminal apparatus transmits transmission signal by MIMO or selects a second transmission method if not; and a transmission unit which transmits transmission method selection information indicating the selected first or second transmission method to the terminal apparatus, wherein the terminal apparatus transmits the transmission signal by the selected first or second transmission method.

Furthermore, according to an another aspect of the present invention, a radio communication system, including: a terminal apparatus; and a base station apparatus, wherein radio communication is performed between the terminal apparatus and the base station apparatus, the base station apparatus includes: a selection unit which selects one of a first transmission method or a second transmission method on the basis of transmission power of transmission signal transmitted from the terminal apparatus; and a transmission unit which transmits transmission method selection information indicating the selected first or second transmission method, and the terminal apparatus includes: a reception unit which receives the transmission method selection information; and a transmission unit which transmits the transmission signal to the base station apparatus by the first or said second transmission method on the basis of the transmission method selection information.

Furthermore, according to an another aspect of the present invention, a radio communication system, including: a terminal apparatus; and a base station apparatus, wherein radio communication is performed between the terminal apparatus and the base station apparatus, the base station apparatus includes: a selection unit which selects a first transmission method if the terminal apparatus transmits transmission signal by MIMO, or selects a second transmission method if not; and a transmission unit which transmits transmission method selection information indicating the selected first or second transmission method, and the terminal apparatus includes: a reception unit which receives the transmission method selection information; and a transmission unit which transmits the transmission signal to the base station apparatus by the first or second transmission method on the basis of the transmission method selection information.

Furthermore, according to an another aspect of the present invention, a radio communication system, including: a terminal apparatus; and a base station apparatus, wherein radio communication is performed between the terminal apparatus and the base station apparatus, the base station apparatus or the terminal apparatus includes: a modulation unit which is adaptable to a plurality of transmission method selected in accordance with magnitude of transmission power; and a transmission unit which transmits signal modulated by the modulation unit, and the plurality of transmission method include SC-FDMA method and OFDM method, and a selection is performed to switch from the OFDM method to the SC-FDMA method in response to increase in the transmission power.

Advantageous Effect of the Invention

According to the present invention, the inconvenient which occurs when the SC-FDMA is applied, can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a configuration example of a radio communication system;

FIG. **2** illustrates a configuration example of a terminal apparatus;

FIG. **3** illustrates a configuration example of a base station apparatus;

FIG. **4** illustrates an example of an MPR table;

FIG. **5** illustrates an example of a sequence diagram indicating an overall operation;

FIG. **6** illustrates a flowchart of an operational example indicating transmission method determination processing;

FIG. **7**A and FIG. **7**B illustrate examples of transmission power decrease widths;

FIG. **8** illustrates a flowchart of another operational example of transmission method determination processing;

FIG. **9** illustrates an example of an MPR table;

FIG. **10** illustrates a flowchart of another operational example of transmission method determination processing;

FIG. **11** illustrates another configuration example of a base station apparatus;

FIG. **12** illustrates another configuration example of a base station apparatus;

FIG. **13** illustrates a flowchart of another operational example of transmission method determination processing;

FIG. **14** illustrates a flowchart of another operational example of transmission method determination processing;

FIG. **15** illustrates another configuration example of a terminal apparatus;

FIG. **16** illustrates another configuration example of a base station apparatus;

FIG. **17** illustrating a flowchart of another example of overall processing;

FIG. **18** illustrates a configuration example of a signal processing circuit in a case where SC-FDMA is employed;

FIG. **19** illustrates a configuration example of a signal processing circuit in a case where OFDM is employed; and

FIG. **20** illustrates a graph of characteristic example of SC-FDMA and OFDM.

EXPLANATION OF REFERENCE NUMERALS

1 radio communication system
10 (**10-1** to **10-3**) terminal apparatus
11 known signal reception unit
12 path loss calculation unit
13 transmission power calculation unit
14 known signal transmission unit
15 Δ(maximum power−current power) transmission unit
17 scheduling transmission unit
18 transmission method reception unit
19 data signal modulation unit
20 data signal transmission unit
50 (**50-1** to **50-4**) base station apparatus
51 known signal transmission unit

52 Δ(maximum power−current power) reception unit
53 scheduling request reception unit
54 MPR table
55 transmission method determination unit
56 transmission method transmission unit
57 data reception unit
60 transmission bit count table
70 network reception unit

BEST MODE FOR CARRYING OUT THE INVENTION

Best mode for carrying out the present invention will be described below.

[First Embodiment]

First, a first embodiment will be described. FIG. **1** illustrates a configuration example of a radio communication system **1**. The radio communication system **1** includes terminal apparatuses ("terminals" hereinafter) **10-1** to **10-3** and base station apparatuses ("base stations" hereinafter) **50-1** to **50-4**. Dotted lines indicate cell ranges of the respective base stations **50-1** to **50-4**. When the terminals **10-1** to **10-3** are positioned in a cell, the terminals **10-1** to **10-3** can perform radio communication with the corresponding base stations **50-1** to **50-4**.

FIG. **2** and FIG. **3** illustrates configuration examples of the terminal **10** and the base station **50**, respectively. The terminal **10** includes a known signal reception unit **11**, a path loss calculation unit **12**, a transmission power calculation unit **13**, a known signal transmission unit **14**, a Δ(maximum power−current power) transmission unit (Δ transmission unit hereinafter) **15**, a transmission data buffer **16**, a scheduling request transmission unit **17**, a transmission method reception unit **18**, a data signal modulation unit **19**, and a data signal transmission unit **20**.

The known signal reception unit **11** receives a known signal from the base station **50** and outputs the received known signal to the path loss calculation unit **12**. For example, the known signal is transmitted periodically from the base station **50**.

The path loss calculation unit **12** calculates a downlink direction propagation path loss (a path loss PL) relative to the base station **50** on the basis of the known signal, and outputs the calculated path loss PL to the transmission power calculation unit **13**.

The transmission power calculation unit **13** calculates a transmission power on the basis of the path loss PL and so on. A following equation is used in the calculation.

$$P_t = P_{max} \times \min\left\{1, \max\left[R_{min}, \left(\frac{PL}{PL_{x-ile}}\right)^x\right]\right\} \quad \text{[Numeral 1]}$$

Here, P_t indicates a data transmission power of the terminal **10** envisaged in accordance with the position of the terminal **10**, P_{max} is a maximum transmission power determined from capacity of the terminal **10**, PL is the path loss, and PL_{x-ile} and R_{min} are constants of power control. The maximum transmission power P_{max} and the two constants PL_{x-ile}, R_{min} are stored in a memory, for example, the transmission power calculation unit **13** reads from the memory, and calculates together with the path loss PL from the path loss calculation unit **12**.

The known signal transmission unit **14** transmits the known signal periodically to the base station **50**, for example.

The Δ transmission unit **15** calculates a difference Δ between the maximum transmission power P_{max} and the transmission power P_t, and transmits the calculated difference Δ to the base station **50**. The difference Δ indicates a decrease width from the maximum transmission power P_{max} corresponding to a current position of the terminal **10**. Note that the difference Δ may be calculated by the transmission power calculation unit **13**.

The transmission data buffer **16** stores transmission data from an application unit or the like.

The scheduling request transmission unit **17** transmits a scheduling request to the base station **50** when transmission data is transmitted. The scheduling request transmission unit **17** calculates data amount of the transmission data stored in the transmission data buffer **16** or the like, and transmits the scheduling request including the data amount and a data rate.

The transmission method reception unit **18** receives a transmission method transmitted from the base station **50** and outputs to the data signal modulation unit **19**.

The data signal modulation unit **19** reads the transmission data from the transmission data buffer **16** and modulates the transmission data on the basis of the transmission method from the transmission method reception unit **18**.

The data signal transmission unit **20** transmits the modulated transmission data to the base station **50**.

On the other hand, as illustrated in FIG. **3**, the base station **50** includes a known signal transmission unit **51**, a Δ (maximum power−current power) reception unit (Δ reception unit hereinafter) **52**, a scheduling request reception unit **53**, an MPR (Maximum Power Reduction) table **54**, a transmission method determination unit **55**, a transmission method transmission unit **56**, and a data reception unit **57**.

The known signal transmission unit **51** transmits the known signal to the terminal **10** periodically, for example.

The Δ reception unit **52** receives the difference Δ from the terminal **10** and outputs to the transmission method determination unit **55**.

The scheduling request reception unit **53** receives the scheduling request from the terminal **10** and outputs to the transmission method determination unit **55**.

The MPR table **54** stores respective values of a transmission method (OFDM or SC-FDMA), a modulation scheme (QPSK, 16QAM, and so on), a number of resource blocks (a number of sub-carriers that can be allocated on a frequency axis), and a reduction amount (a transmission power reduction amount hereinafter) P_r from the maximum transmission power of the terminal **10**.

The terminal **10** includes an amplifier to transmit the transmission data, and the transmission power reduction amount P_r is a value indicating a decrease width by which the transmission power must be reduced from the maximum transmission power in order to satisfy so-called ACLR (the upper limit value of out-of-band emission power) due to constraint of the amplifier in the terminal **10**.

FIG. **4** illustrates an example of the MPR table **54**. As illustrated in FIG. **4**, the value of the transmission power reduction amount P_r differ in accordance with the transmission method, the modulation scheme, and the number of resource blocks. The reason is that transmission waveform transmitted from the terminal **10** differs according to the transmission method and so on, and the transmission power reduction amount P_r takes different value according to the transmission waveform. If the transmission method is different even if the modulation scheme and the number of resource brocks are same, the transmission power reduction amount P_r is different. The reason is that in OFDM, the PAPR of the transmission power is larger than in SC-FDMA, and therefore the transmission power must be reduced to satisfy the ACLR.

Returning to FIG. **3**, the transmission method determination unit **55** determines the transmission method by selecting one of OFDM and SC-FDMA in accordance with the difference Δ and a maximum value of the transmission power reduction amount P_r read from the MPR table **54**. Determination processing will be described below. The transmission method determination unit **55** performs the determination processing when the scheduling request reception unit **53** receives the scheduling request, for example.

The transmission method transmission unit **56** transmits the determined transmission method. The terminal **10** transmits the transmission data on the basis of the transmission method (see FIG. **2**).

The data reception unit **57** receives the transmission data from the terminal **10** and performs reception processing on the basis of the transmission method.

Next, the transmission method determination processing will be described in detail. FIG. **5** illustrates an example of a sequence diagram indicating an overall operation, and FIG. **6** illustrates a flowchart indicating an example of the transmission method determination processing.

First, the known signal transmission unit **51** of the base station **50** transmits the known signal to the terminal **10** (S**10**).

Next, the transmission power calculation unit **13** of the terminal **10** calculates the difference Δ between the maximum transmission power P_{max} and the transmission power P_t of the terminal **10** corresponding to its position (S**11**).

Next, the scheduling request transmission unit **17** of the terminal **10** transmits the scheduling request (S**12**). The Δ transmission unit **15** transmits the difference Δ at the transmission timing of the scheduling request. The Δ transmission unit **15** outputs the calculated difference Δ to the scheduling request transmission unit **17**, and the scheduling request transmission unit **17** may transmit the scheduling request including the difference Δ.

Next, the transmission method determination unit **55** of the base station **50** determines the transmission method (S**13**).

Next, the processing shifts to the transmission method determination processing (FIG. **6**), in which the transmission method determination unit **55** compares the maximum value of the transmission power reduction amount P_r with the difference Δ (S**20**). If the maximum value of the transmission power reduction amount P_r is larger than the difference Δ, the transmission method determination unit **55** selects SC-FDMA (S**21**). On the other hand, if the maximum value of the transmission power reduction amount P_r and the difference Δ are identical or the difference Δ is larger than the maximum value of the transmission power reduction amount P_r, the transmission method determination unit **55** selects OFDM (S**22**).

Alternatively, the transmission method determination unit **55** may select SC-FDMA if the base station **50** detects that the transmission power of the mobile station exceeds a predetermined threshold, and may select OFDM if the base station **50** detects that the transmission power of the mobile station is smaller than the predetermined threshold.

The reason for comparing the two values in this manner will now be described with reference to FIG. **7**A and FIG. **7**B. FIG. **7**A illustrates an example in which the transmission power is set on the ordinate and the maximum value of the transmission power reduction amount P_r is larger than the difference Δ. FIG. **7**B illustrates an opposite example.

As described above, the difference Δ indicates the transmission power decrease width from the maximum transmission power corresponding to the position of the terminal **10**. On the other hand, (the maximum value of) the transmission power reduction amount P_r indicates (a maximum value of) the decrease width by which the transmission power must be reduced from the maximum transmission power due to the constraints of the amplifier in order to satisfy the linearity of the amplifier in the terminal **10** and thereby satisfy the ACLR (the upper limit value of the out-of-band emission power). If (the maximum value of) the transmission power reduction amount P_r is larger than the difference Δ (see FIG. **7**A), this indicates that the terminal **10** should be capable of transmission at the decrease width Δ in accordance with its position, but the terminal **10** may transmit by excess reduced power due to the constraints of the amplifier.

A case in which the transmission power is reduced further due to the constraints of the amplifier corresponds to a case in which the terminal **10** is far from the base station **50**. In other words, as described in the prior art, the PAPR is larger in OFDM than in SC-FDMA, and therefore, in OFDM, an average transmission power must be reduced below that of SC-FDMA in order to satisfy the linearity of the amplifier and thereby satisfy the ACLR standard. If the terminal **10** is positioned far from the base station **50**, data is transmitted at the maximum transmission power as much as possible in order to increase a reception characteristic of the base station **50**.

However, since the PAPR is large in OFDM, the average transmission power must be reduced to satisfy the linearity of the amplifier. If there is a case where the transmission power must be reduced in accordance with OFDM, SC-FDMA has better the reception characteristic of the base station **50**, in which the average transmission power is large, than OFDM.

Hence, if the transmission power is reduced further due to the constraints of the amplifier, or in other words if the maximum value of the transmission power reduction amount P_r is larger than the difference Δ (FIG. **7**A), the transmission method determination unit **55** selects SC-FDMA as the transmission method.

On the other hand, if the difference Δ is equal to or greater than (the maximum value of) the transmission power reduction amount P_r (FIG. **7**B), the power decrease width Δ corresponding to the position is equal to or greater than (the maximum value of) the transmission power reduction width P_r from the constraints of the amplifier, and therefore the transmission power is reduced sufficiently to satisfy the constraints of the amplifier. If the transmission power can be reduced in this manner, data can be transmitted sufficiently even if the terminal **10** is close to the base station **50**, and even if data are transmitted using OFDM having a high PAPR, both the linearity of the amplifier and the ACLR are satisfied.

Hence, if the transmission power is low, or in other words if the transmission power reduction amount P_r is equal to or smaller than the difference Δ, the transmission method determination unit **55** selects OFDM. By the selection of OFDM, a radio characteristic is improved in comparison with SC-FDMA and scheduling is flexible.

In the first embodiment, the transmission method determination unit **55** reads from the MPR table **54** the maximum value (4.5 dB in the example illustrated in FIG. **4**) of the transmission power reduction amount P_r. Alternatively, the maximum value of the transmission power reduction amount P_r is stored in the MPR table **54** alone as a threshold. The transmission method determination unit **55** may then compare the threshold with the difference Δ.

Returning to FIG. **5**, the transmission method transmission unit **56** of the base station **50** notifies the determined transmission method to the terminal **10** (S**14**).

The data signal modulation unit **19** of the terminal **10** modulates the transmission data in accordance with the notified transmission method (S**15**).

Next, the data signal transmission unit **20** of the terminal **10** transmits the data signal to the base station **50** (S**16**).

Next, the data reception unit **57** of the base station **50** demodulates the data signal in accordance with the selected transmission method (S**17**). The series of processes is then terminated.

Hence, in this embodiment, data are not transmitted uniformly by SC-FDMA on the uplink, and the data may be transmitted after switching to OFDM, for example. OFDM has better radio characteristic than SC-FDMA, and therefore an improvement in the radio characteristic can be achieved in comparison with a case in which the data are transmitted uniformly by SC-FDMA.

Further, with OFDMA, resource allocation scheduling not using sub-carriers that are continuous on the frequency axis can be performed, and therefore scheduling flexibility can be secured in comparison with a case in which the data are transmitted uniformly by SC-FDMA.

As a result, an improvement in throughput can be achieved.

Note that in the example described above, the determinations as to whether or not the transmission power of the terminal **10** has exceeded the predetermined threshold and whether or not the maximum value of the transmission power reduction amount P_r is larger than the difference Δ are made in the base station **50**, but the mobile station may include the transmission method determination unit **55**.

By inputting the difference Δ and the transmission power as is into the transmission method determination unit **55** of the mobile station from the transmission power calculation unit **13**, the transmission method can be determined by the mobile station.

More specifically, when the transmission method determination unit **55** of the mobile station detects that its own transmission power has exceeded the predetermined threshold or that the maximum value of the transmission power reduction amount P_r is larger than the difference Δ, the transmission method determination unit **55** controls the data modulation unit **19** such that transmission is performed using the SC-FDMA method.

Also, when the transmission method determination unit **55** of the mobile station detects that its own transmission power is lower than the predetermined threshold or that the maximum value of the transmission power reduction amount P_r is smaller than the difference Δ, the transmission method determination unit **55** controls the data modulation unit **19** such that transmission is performed using the OFDM method.

Preferably, before switching the method, the base station **50** can notify the switch destination method (the SC-FDMA method or the OFDM method) before the method is switched by making the switch destination method transmit to the base station **50** from the data signal transmission unit **20**. Even if the notification is not performed, the switch destination method can be detected by having the base station **50** perform reception processing in relation to both methods respectively.

Further, an embodiment in which the positions of the base station and the mobile station are interchanged may be applied.

[Second Embodiment]

Next, a second embodiment will be described. In the first embodiment, the transmission method determination unit **55** compares the maximum value of the transmission power reduction amount P_r with the difference Δ. In the second embodiment, the transmission method is determined by comparing the transmission power reduction amount P_r with the difference Δ, after selecting the modulation method and the number of resource blocks, and reading corresponding items from the MPR table **54**.

The overall configuration of the radio communication system **1** and the respective configurations of the terminal **10** and the base station **50** are identical to those of the first embodiment (see FIG. **1** to FIG. **3**). Further, the processing up to the point at which the base station **50** receives the scheduling request from the terminal **10** (S**12** of FIG. **5**) is similar to that of the first embodiment.

The transmission method determination unit **55** inputs the scheduling request from the scheduling request reception unit **53**, and performs the transmission method determination processing (S**13**).

FIG. **8** illustrates flowchart indicating operational example of the transmission method determination processing, and FIG. **9** illustrates an example of the MPR table **54**.

When the transmission method determination unit **55** selects the transmission method (S**30**), the transmission method determination unit **55** selects on the basis of a determined format (the modulation scheme and the number of resource blocks) (S**31**).

For example, the transmission method determination unit **55** determines a format in which the modulation scheme is "16QAM" and the number of resource blocks is "1". The transmission method determination unit **55** then reads corresponding items from the MPR table **54**. FIG. **9** illustrates an example of the MPR table **54** indicating the corresponding items. The transmission method determination unit **55** then reads the transmission power reduction amount P_r of the OFDM method from the corresponding items. In the example illustrated in FIG. **9**, the transmission power reduction amount P_r is "3". The transmission method determination unit **55** compares the read transmission power reduction amount P_r (="3") of the OFDM method with the difference Δ, and then selects SC-FDMA if the transmission power reduction amount P_r is greater than the difference Δ, and selects OFDM if the transmission power reduction amount P_r is equal to or smaller than the difference Δ, similarly to the first embodiment (S**32**). Subsequent processing is similar to that of the first embodiment.

The reason why the transmission method determination unit **55** reads the transmission power reduction amount P_r of OFDM, from among the two transmission power reduction amounts P_r of OFDM and SC-FDMA, is that the power reduction amount P_r of OFDM is larger than that of SC-FDMA and strict condition becomes standard.

Note that in the second embodiment, the format may be determined by the scheduling request reception unit **53** rather than the transmission method determination unit **55**. In this case, the scheduling request reception unit **53** outputs the determined format to the transmission method determination unit **55**, and the transmission method determination unit **55** performs the processing described above on the basis of the format.

[Third Embodiment]

Next, a third embodiment will be described. The transmission method is selected further taking the transmission bit count into consideration in the third embodiment in comparison with the second embodiment.

The terminal **10** transmits to the base station **50** the scheduling request including a data amount (the transmission bit count) (FIG. **2**, S**12** of FIG. **5**). If the transmission bit count is small, the terminal **10** can reduce the transmission power further. The transmission method determination unit **55** sets a decrease width corresponding to the transmission bit count as Δ**1** and determines the transmission method by comparing (Δ+Δ**1**) (decrease width (Δ+Δ**1**) hereinafter) with the transmission power reduction amount P_r.

The configurations of the radio communication system **1**, the terminal **10**, and the base station **50** according to the third embodiment are similar to those of the first embodiment. However not that the transmission method determination unit **55** determines the power decrease width **Δ1** corresponding to the transmission bit count. For example, the determination is such that the transmission method determination unit **55** includes a table of decrease widths **Δ1** corresponding to transmission bit counts and reads the decrease width **Δ1** corresponding to the transmission bit count from the table of decrease width **Δ1**. Alternatively, the transmission method determination unit **55** stores inside a formula for calculating the decrease width from the transmission bit count, may calculates and determine the decrease width **Δ1** from the formula. Alternatively, the base station apparatus **50** further includes a transmission bit count table **60** as illustrated in FIG. **11**, and the transmission method determination unit **55** may read the decrease width **Δ1** corresponding to the transmission bit count.

FIG. **10** illustrates a flowchart indicating an example of transmission method determination processing according to the third embodiment. This processing is similar to the processing of the first embodiment up to the point at which the base station **50** receives the scheduling request.

If the transmission method determination unit **55** inputs the scheduling request from the scheduling request reception unit **53**, the transmission method determination unit **55** determines the power decrease width **Δ1** on the basis of the transmission bit count included in the scheduling request (S**41**) and selects the transmission method corresponding to the format in the similar manner to the second embodiment (S**40**, S**42**).

And, if the power reduction amount P_r of OFDM is larger than the decrease width (Δ+**Δ1**), the transmission method determination unit **55** selects SC-FDMA, and if the power reduction amount P_r of OFDM is not larger than the decrease width (Δ+**Δ1**), the transmission method determination unit **55** selects OFDM (S**43**). In other words, if the amount of transmission data is small enough to be transmitted at a low transmission power, OFDM is selected, and if not, SC-FDMA is selected. Subsequent processing is similar to that of the first embodiment.

Further, note that in the third embodiment, an encoding ratio may be used in addition to the transmission bit count. The transmission bit count table **60** stores decrease widths **Δ1** corresponding to encoding ratios. When the scheduling request reception unit **53** receives the scheduling request, the scheduling request reception unit **53** determines the encoding ratio and outputs to the transmission method determination unit **55**. The transmission method determination unit **55** then determines the transmission method by reading the decrease width **Δ1** corresponding to the encoding ratio from the table **60**.

[Fourth Embodiment]

Next, a fourth embodiment will be described. In the fourth embodiment, if the base station **50** receives an instruction to reduce the power of the terminal **10** from a network (another base station, for example, although the network may be the base station **50** itself), the transmission method is determined taking into consideration a power decrease width **Δ2** corresponding to the instruction.

The instruction is also known as an Overload Indicator, and if the transmission power of the terminal **10** is large such that interference is applied to the terminal of another cell, the transmission power of the terminal **10** is reduced in accordance with the instruction.

The configuration of the radio communication system **1** and the terminal **10** is similarly to their counterparts in the first embodiment. FIG. **12** illustrates a configuration example of the base station **50**. As illustrated in the FIG. **12**, the base station **50** includes a network reception unit **70** so as to be capable of receiving the instruction (Overload Indicator) from another base station via the network.

FIG. **13** illustrates a flowchart indicating an example of the transmission method selection processing. The processing up to the point at which the base station **50** receives the scheduling request (S**12** in FIG. **5**) is similar to that of the first embodiment.

If the network reception unit **70** receives the instruction from another base station, the network reception unit **70** outputs the power decrease width **Δ2** corresponding to the instruction (S**50**). For example, the network reception unit **70**A includes inside a table, and reads the corresponding decrease width **Δ2** from the table and outputs.

The transmission method determination unit **55** determines the format in a similar manner to the second embodiment (S**52**), reads the corresponding items from the MPR table **54**, compares the decrease width (Δ+**Δ2**) with the transmission power reduction amount P_r of OFDM, and determines the transmission method (S**51**, S**53**).

More specifically, if the power reduction amount P_r of OFDM is larger than the decrease width (Δ+**Δ2**), the transmission method determination unit **55** selects SC-FDMA, and if the power reduction amount P_r of OFDM is not larger than the decrease width (Δ+**Δ2**), the transmission method determination unit **55** selects OFDM (S**53**). In other words, if transmission can be performed at a sufficiently low transmission power in accordance with the instruction, OFDM is selected, and if not, SC-FDMA is selected. Subsequent processing is similar to that of the first embodiment and so on.

[Fifth Embodiment]

Next, a fifth embodiment will be described. The fifth embodiment is an example of a case in which the transmission method is determined according to whether or not the terminal **10** performs MIMO (Multiple-Input Multiple-Output) transmission.

MIMO is a method for obtaining a transmission signal by receiving transmission signal transmitted from a plurality of transmission antennae in a single reception antenna and synthesizing the reception signal such that the reception signal is canceled. MIMO is used to obtain further throughput in an environment having a favorable reception SIR (Signal to Interference Ratio).

However, if transmission is performed using SC-FDMA, the reception signal is processed on a reception side by using a frequency equalizer, and due to the frequency equalizer, inter-stream interference cannot be eliminated. As a result, weighting coefficients relating respectively to the MIMO inter-stream interference and multipath interference become contradictory, and problem to deteriorate the reception signal characteristic occurs.

On the other hand, in OFDM, the reception side may not use the frequency equalizer and the sub-carrier is orthogonal, and therefore multipath interference does not occur during reception signal processing even if any weighting coefficient is used. Accordingly, reception can be performed using the weighting coefficient for eliminating the inter-stream interference of MIMO.

Hence, the transmission method determination unit **55** according to the fifth embodiment selects OFDM if MIMO transmission is to be performed, and selects SC-FDMA if MIMO transmission is not to be performed (S**60** to S**62** in FIG. **14**).

The scheduling request transmission unit **17** of the terminal **10** transmits the scheduling request including an information indicating whether or not MIMO transmission is to be performed. The transmission method determination unit **55** may read the information from the scheduling request, and determine the transmission method.

If MIMO transmission is performed, the data is transmitted from the terminal **10** by using OFDMA, and therefore the radio characteristic of the reception signal deteriorates to a smaller extent than if transmission is performed by using SC-FDMA.

[Sixth Embodiment]

Next, a sixth embodiment will be described. In the first to fifth embodiments, the calculation of the difference Δ is performed in the terminal **10**. The sixth embodiment is an example of a case in which the base station **50** calculates the difference Δ.

FIG. **15** and FIG. **16** illustrates a configuration example of the terminal **10** and the base station **50** respectively, and FIG. **17** illustrates a sequence diagram of overall processing. In the sixth embodiment, the base station **50** calculates the difference Δ, and therefore the base station **50** includes the known signal reception unit **11**, the path loss calculation unit **12**, and the transmission power calculation unit **13**.

The known signal transmission unit **14** of the terminal **10** transmits the known signal to the base station **50** (S**70**).

Next, the known signal reception unit **11** of the base station **50** receives the known signal, and the transmission power calculation unit **13** calculates the difference Δ between the maximum transmission power P_{max} and the transmission power P_t corresponding to the current position, by using (Numeral 1) and so on (S**71**). Subsequent processing is similar to that of the first embodiment. The sixth embodiment may also be applied to any of the second to fourth embodiments.

The invention claimed is:

1. A radio communication method in a radio communication system which performs radio communication between a terminal apparatus and a base station apparatus, the radio communication method comprising:

selecting a first transmission method if the terminal apparatus transmits transmission signal by MIMO or selecting a second transmission method if the terminal apparatus transmits the transmission signal regardless of MIMO, in the base station apparatus; and

transmitting the transmission signal to the base station apparatus by the selected first or second transmission method, in the terminal apparatus.

2. The radio communication method according to claim **1**, wherein PAPR of the first transmission method is larger than PAPR of the second transmission method.

3. A terminal apparatus for performing radio communication with a base station apparatus, the terminal apparatus comprising:

a reception unit which receives from the base station apparatus transmission method selection information indicating that a first transmission method is selected if the terminal apparatus transmits transmission signal by MIMO or a second transmission method is selected if the terminal apparatus transmits the transmission signal regardless of MIMO; and

a transmission unit which transmits the transmission signal to the base station apparatus by the first or second transmission method based on the transmission method selection information.

4. The radio communication method according to claim **3**, wherein PAPR of the first transmission method is larger than PAPR of the second transmission method.

5. A base station apparatus for performing radio communication with a terminal apparatus, the base station apparatus comprising:

a selection unit which selects a first transmission method if the terminal apparatus transmits transmission signal by MIMO or selects a second transmission method if the terminal apparatus transmits the transmission signal regardless of MIMO; and

a transmission unit which transmits transmission method selection information indicating the selected first or second transmission method to the terminal apparatus,

wherein the terminal apparatus transmits the transmission signal by the selected first or second transmission method.

6. The radio communication method according to claim **5**, wherein PAPR of the first transmission method is larger than PAPR of the second transmission method.

7. A radio communication system, comprising:

a terminal apparatus; and

a base station apparatus, wherein

radio communication is performed between the terminal apparatus and the base station apparatus,

the base station apparatus includes:

a selection unit which selects a first transmission method if the terminal apparatus transmits transmission signal by MIMO, or selects a second transmission method if the terminal apparatus transmits the transmission signal regardless of MIMO; and

a transmission unit which transmits transmission method selection information indicating the selected first or second transmission method, and

the terminal apparatus includes:

a reception unit which receives the transmission method selection information; and

a transmission unit which transmits the transmission signal to the base station apparatus by the first or second transmission method based on the transmission method selection information.

8. The radio communication method according to claim **7**, wherein PAPR of the first transmission method is larger than PAPR of the second transmission method.

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